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# THE ELECTRIC FENCE IN WILDLIFE MANAGEMENT

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It goes without saying that a practical device for keeping animals inside or outside of certain areas would be of utmost value to wildlife managers. Electrified fence seems to have possibilities in that direction; its merits and demerits as revealed to date are the subject of this compilation.

Soon following increase as a result of lumbering or protection, or both, in the number of deer in older States having a rather dense human population came complaints of damage in gardens, fields, and orchards. Difficulty in appraising the damage and in eliminating fraudulent claims have been among the perplexities of State game commissions for decades. If these troubles can be cured by an economical and effective deterrent, a very great gain will have been made. Experience indicates that in the electric fence the solution of these and similar problems may be at hand, and that this device needs only perfecting, and constantly cautious and intelligent use, to become a tool of great utility to game administrators and wildlife managers.

## DESCRIPTION

The electric fence, for ordinary uses, may, and preferably should, be simple, consisting of one or a few strands of smooth wire, the height of which from the ground must be regulated according to the size and habits of the animals to be controlled. Trial and adjustment in this respect may be necessary.

With low voltages, barbed wire has been found best for warding off animals with copious hair as the points of the barbs penetrate to the skin and make an effective contact for the current. High voltages (700 or more) carry through the hair.

The wires may be supported by temporary or permanent posts or by trees or other objects, provided in all cases they are kept taut and efficiently insulated. This may be accomplished by the usual commercial devices or by loops of old inner tubes or of rubber hose. The more perfect the insulation, however, the better. Thus posts of wood are preferable to those of metal.

Trial in Yellowstone National Park proved the split-knob type of insulators best. They may be applied in such a way as to keep the wire from coming in contact with the posts even when subjected to considerable pressure. (Rudolf L. Grimm, Report of March 21, 1938.)

The fence line must be kept clear of growth (grass, weeds, limbs of bushes or of trees) that may touch the wires and short the current.

In regions where large "tumbleweeds" like Russian thistle are common, they

may be blown against the fence and ground the current. Frequent inspections of the line are necessary to eliminate shorts. (Rudolf L. Grimm, Report of March 21, 1938.)

Higher voltages leak away more readily than lower. The former are more effective in dry regions where the ground contact is not good. Where the soil is very dry for long periods, this connection may have to be improved by positive grounding through deep-driven metal stakes; by the use of a two-way circuit, one of the wires carrying the "ground" current; or by providing an artificial "ground" by spreading a mat of wire mesh along the fence.

Dry snow also is a poor conductor and in some regions may limit the usefulness of electric fences in winter. The shock conveyed is greater when the ground is wet, hence fences have been placed along or in streams or in other places where the animals will be standing on wet soil or in water when they come in contact with the fence. (Rudolf L. Grimm, Report of March 21, 1938.) It should be borne in mind that this practice may greatly increase the hazards.

Electricity has been supplied from a variety of sources as batteries (about 6 volts), home power plants (32 volts), or the ordinary alternating current domestic supply (110 volts). In the order named, these sources are more and more dangerous and the current from them is progressively in need of transformation and control. Modification of current that is to pass through naked wires that may be touched by people and livestock as well as by wild animals is not a proper subject for amateur experimentation. The current controller is the most important part of the fence and should be of a type that has received official approval of the proper State commissions. (See Pinches, 1938.) A modern code of requirements is contained in the report cited in the bibliography under Wisconsin Industrial Commission. To be entirely on the safe side, it is recommended that only battery installations be used in wildlife management until the precise effects of electrical shock are better understood and equipment has been so perfected that there is no doubt as to its safety. Batteries have the advantage in districts having considerable winds, that a wind driven generator can be used to recharge them. (See McColly and Buck, 1936.)

Electric current in a wire has been compared to a stream of water in a pipe. Voltage (current potential) of the electricity corresponds to the pressure, and amperage (current intensity) to the volume, of the water stream. It is known that under conditions assuring good contact the ordinary domestic supply voltage of 110 at one ampere may be fatal to a person. Warning signs on electrical equipment tell of the number of volts but amperage or intensity is the dangerous thing. An expert who has carefully studied the subject recommends for an installation with smooth wire and high voltage a current of 10/1000 of an ampere or even less. Prevailing commercial devices for modifying current for use in fences pass about 10–13 millamperes. Batteries of moderate capacity are entirely satisfactory sources of current for electric fences and with equally portable control apparatus constitute the only practicable equipment for

operating electric fences in remote areas, just where the wildlife manager is most likely to need them.

The charge on the wire should be intermittent. This is advisable not only to prevent, under any circumstances, "freezing" of any victim to the wire, but also because repetition of shock increases the deterrent effect. Safe apparatus should provide further for automatic shutting off of all current upon failure of any part.

In the control of wildlife, costs of electrified fence will often be less than those incurred when the fence must be an actual barrier. The necessity of fencing against a variety of animals, however, and of repelling creatures that seem more ingenious and persistent than domestic stock probably will often make the fencing problem a more complicated one than it is on the farm. Even with electric fence, sturdy construction is required for use against such powerful animals as bear, elk, and bison.

Farm experience indicates that current controllers handle efficiently 10–15 miles of one-wire, or 5 miles of woven, fence and that current costs for that mileage may average as low as from 10–25 cents a month. It is reported (*Time*, May 2, 1938, p. 32) that "there are some 250,000 miles of electric fence in use on more than 100,000 U. S. farms."

## REPORTS OF EXPERIENCE

The items under this head are arranged alphabetically, primarily according to the animal, and secondarily as to the State, concerned.

### *Antelope*

So far as observed in a Yellowstone National Park experiment, a single-strand electric fence with the wire 30 inches from the ground, was entirely effective in keeping antelope out of an area where formerly they had fed. They even shunned the tract after removal of the fence. (Rudolf L. Grimm, Report of March 21, 1938.)

### *Bear*

Storer, Vansell, and Moses (1938) report that bears have been kept away from apiaries in California by electric fence but the fence must be substantial. It must have at least 4 strands of barbed-wire, all charged, and must be thoroughly grounded to a metal stake driven deep enough to reach damp earth or provided with an artificial "ground" of poultry netting. The time between successive impulses of the current must not be long enough to permit an animal to pass through the fence during the interval. An interrupter that breaks the circuit about 50 times a minute is recommended.

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In Pennsylvania experiments to protect apiaries and cornfields from bears, results were inconsistent but the indications were "that bears can not be successfully controlled by units using as low as six-volt currents." (Gerstell, 1938, p. 32.)

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In Yellowstone National Park electrified barbed wire was effective in keeping black bears away from a fish trap that was maintained to get fishes for spawning operations. (Maynard Barrows, letter of November 26, 1937.)

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In National Parks, "Electrically charged wire fences are used to repel bears from sources of food where the

public will not be endangered. These are inexpensive and entirely satisfactory in frightening away the bears, but unfortunately this method is not safe for general application." (Cahalane, 1938.)

*Buffalo*

On the Davison Ranch near Arnett, Oklahoma, it was found feasible to control buffalo with a single strand of barbed wire connected to a commercial electrifier. This was an accomplishment previously found impossible, during a period of 17 years, by the use of an 8-strand barbed-wire fence 8 feet high. (Verne E. Davison, letter of April 15, 1938.)

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In the buffalo show pasture at Yellowstone National Park, several small hills were being overgrazed. An electric fence of 3 strands of barbed wire, spaced about 18 inches apart, was set up around one of these hills. So long as supplied with current it kept the buffalos out. (Maynard Barrows, letter of November 26, 1937.)

*Cat*

Two large pheasant farms near Janesville, Wisconsin, use electric wires around their bird pens to keep out cats. In winter when snow accumulated it enabled the cats to jump to the top of the fence but an electrified wire there stopped the trouble. (Nicholson, 1937, pp. 72–73.)

*Coyote*

"Reports from Texas indicate that electrified wires enclosing a range may cut down the coyote nuisance." (Nicholson, 1937, p. 72.)

*Deer*

"We have been experimenting with this type of deer control for two years but so far all of our experiments have been failures. This has been due, I am sure, to the fact that we have confined all of our experiments so far to the one-wire fence. Our experiments of last season showed us that the one-wire fence will never prove effective under California conditions and we are planning on going ahead this year with a two-wire setup.

"In California we are faced, of course with a long dry season which so far has made any setup used ineffective by the first of August at the latest. Enough damage may be done during the months of August and September to more than offset any benefits obtained by the use of the fence before the ground became dry." (Gordon H. True, letter of March 28, 1938.)

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"The Florida State Live Stock Sanitary Board is constructing 80 miles of electric fence for the purpose of restricting the movement of deer.

"This 80 miles of fence constitutes a six-strand, heavy-duty barbed wire barrier and runs from the Gulf of Mexico, near Estero, Florida, east into the Everglades, south of Lake Okeechobee. The deer in the area south of this fence are infested with the cattle-fever tick and the cattle north of the fence are free of ticks, and it is our purpose to restrain the tick-infested deer to the area south of the fence, and thus prevent the spread of the ticks. To prevent any movement of deer, we have electrified the first, second, third, and fifth wires of this fence, each wire being

charged independently of the others so that it can be disconnected in case of short circuit, high water or other complication, affecting only one wire at a time, but still providing for an electrified fence through the other wires (Plate 1).

"Unfortunately, this is a wide open rough country, and it is impossible to observe that deer are being repelled by the fence. This fact can only be determined through the course of time, in the event that ticks do not spread to the north side, evidence in itself that the deer are not passing.

"This fence has only been recently constructed and, therefore, we are not able to advise definitely as to its effectiveness." (J. V. Knapp, letter of March 23, 1938.)

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"From our experiments to date it appears that one strand of barbed wire *properly put up* (tightly stretched about two feet above the ground) may protect vulnerable plantings in areas of heavy deer populations. If, however, the wire is carelessly strung, *after deer have formed the habit of feeding in a field*, or the current left off for considerable periods, these intelligent animals may form the habit of jumping the wire, and it loses its protective value.

"If used to exclude deer, the fence should be put up *before* the animals have formed the habit of raiding the plantings and the current left on at least during the night. Thus handled we have completely protected the central portion of a field of cowpeas and soybeans, while the edges outside the wire were grazed to the ground up to within a few feet of the charged wire. Whether a single charged wire will continue to exclude deer we do not know, for they can be pestiferous creatures where their food is concerned." (Stoddard, 1938, p. 18.)

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During tests in Pennsylvania of the value of electric fencing to keep deer out of cultivated fields, it was found that nearly all of the animals were shocked while smelling the wire or attempting to crawl under it. Two wires were used, one 22, and the other 37, inches above the ground. The installations were more than 90 per cent efficient in preventing the animals from entering fenced plots. (Gerstell, 1938, p. 9.)

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At the base of mountains northeast of Logan, Utah, where deer had been making nightly visits to an apple orchard to feed on buds and twigs, tests were made of three types of electrified fence. The trials were with (1) a single wire just above the top of an existing fence, about 3½ feet from the ground; (2) a separate fence, partly of one wire 22 inches high, and partly of two wires, one 22, the other 46, inches high; and (3) the two wires 26 and 42 inches above the ground. Only the last gave encouraging results and it was nearly 80 per cent efficient in turning incoming deer. In all cases deer frightened when in the inclosure departed regardless of the fence. (Everett R. Doman, Report of May 24, 1938.)

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"During the past few years, deer damage has increased rapidly until now it is a major problem of the Vermont Fish and Game Service. Most of it occurs in the southern county of Wind-

ham, which has the heaviest deer population in the State.

"Some type of fence is the only method of controlling this animal. With standard deer-proof fencing, a large investment is necessary and this restricts its use to very small areas. An electric fence, if effective, would eliminate much of this expense and permit comparatively large areas to be enclosed.

"In the summer of 1936, a small area was enclosed by one of these fences. This was constructed in an orchard on the Scott Farm in Dummerston, where much damage had been done the previous year. Steel posts and three strands of barbed wire were used. The highest strand was placed four and one-half feet above the ground. Deer were not completely excluded, but the following figures illustrate the value of the fence.

| *Area* | *Total Number of Trees* | *Damaged* | *Percentage* |
|---|---|---|---|
| Fenced (electric) | 221 | 18 | 8.1 |
| Adjacent unfenced | 300 | 218 | 72.3 |
| Adjacent unfenced | 25 | 7 | 28.0 |

"These are all young trees, under two years, and are in the most critical period as far as damage by deer is concerned.

"If this one case can be considered as a fair sample, then the electric fence appears to present an effective and economical means of control of deer damage." (R. P. Hunter, letter of April 4, 1938.)

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This spring a number of farmers in the vicinity of Olympia, Washington, have reported good results with electric fences in keeping deer out of strawberry patches. They used a small transformer and a single wire with rubber insulators. (Burton Lauckhart, letter of May 2, 1938.)

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"Preliminary results from Wisconsin indicate that the deer, contrary to popular opinion, will not jump the wire if they can slip under. The result is a healthy shock, and an end to their depredations. Strips of tin or other shiny bits of metal hung on the wire, are a challenge to the deer's curiosity, and hasten their acquaintance with 'touch me not.' " (Plate 2) (Nicholson, 1937, p. 72.)

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An electrified fence with 2 wires, 24 and 42 inches above the ground, respectively, was 90 per cent effective in keeping deer out of a highly favored plot in Yellowstone National Park. These deer had been accustomed to breaking into hay corrals and overcoming other obstructions so no doubt gave the fence a thorough test. A three-strand smooth wire fence kept 20 deer away from a haystack where they had been feeding daily. (Rudolf L. Grimm, Report of March 21, 1938.)

*Elk*

At a range experiment station in Clatsop County, Oregon, the main damage by elk was breaching of ordinary fences, permitting the escape of cattle from enclosed ranges. Tests were made of three different types of electric fencing: (1) electrifying the 3rd and 5th wires of ordinary fence, (2) paralleling at a distance of 30 inches the existing fence, the top wire of which was charged, with a single wire electric fence 40 inches above the ground, and (3) em-

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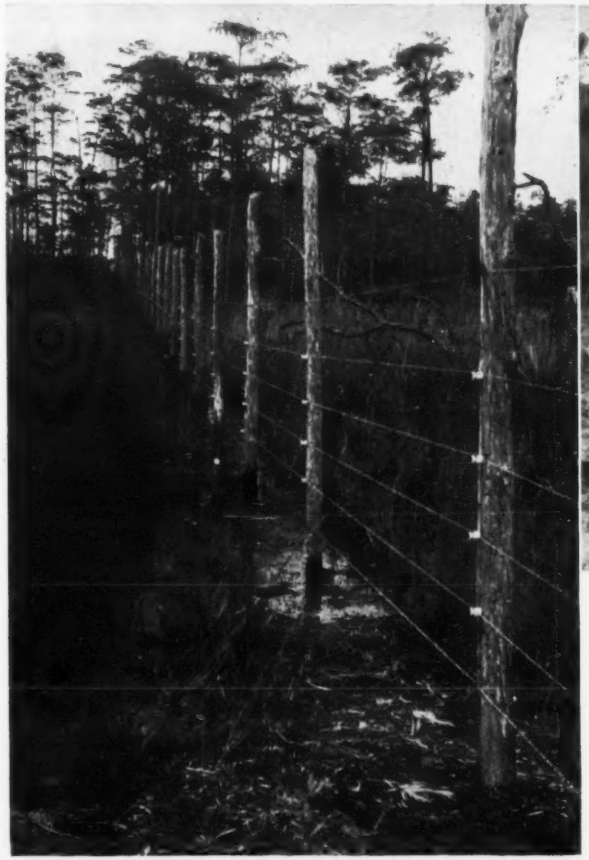
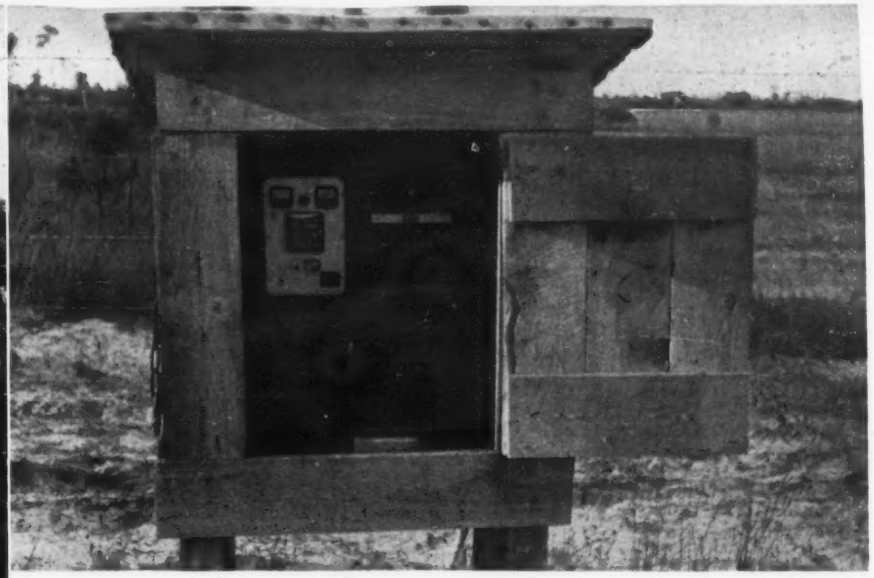
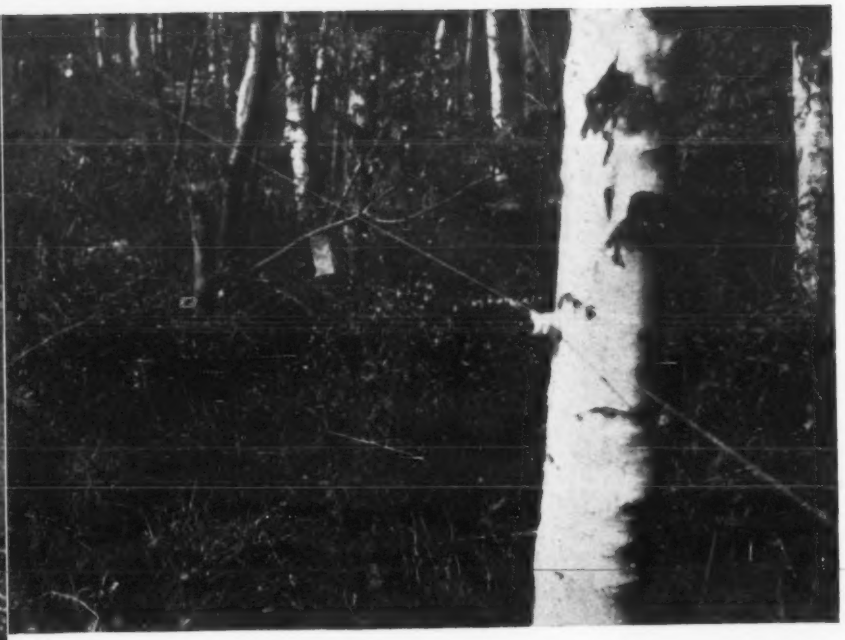




Deer control fence constructed by the Florida State Live Stock Sanitary Board. (*Left*)—Six-strand fence, 4 strands electrified. (*Above*)—Housing, battery, controller, and switches. In case of grounding by rise of water, each wire can be separately disconnected from the battery. (Courtesy Prime Mfg. Co.)



Electrified fences for controlling wildlife in Wisconsin. (*Left*)—To exclude raccoons and other predators from a game bird farm. (*Upper*)—Deer-repellent fence with dangler to attract nosing by the animals thus quickening acquaintance with properties of the fence. (Courtesy Prime Mfg. Co.)

ploying the same construction with only the added single wire electrified. Abstract of the summary of one season's test of the fence is: It has been constructed and operated under difficult conditions because of snow, rain, and fog. The terrain is rough and down logs and brush are abundant, but even so it is regarded as 100 per cent efficient. The type 3 construction appears the most desirable because of ease and low cost of construction, and effectiveness. One power unit also can charge a greater length of such fence as only one wire is electrified. All fences require close attention and prompt repair because elk charging out of a field will not be stopped by any fence. Elk entering a field, however, approach the fence in a different manner and have been turned back satisfactorily. (Arthur S. Einarsen, Report of March 1938.)

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In Utah, elk were kept out of a potato patch they had damaged by trampling and out of grain fields where they had been feeding by the use of electrified fences. (R. L. Turpin, letter of March 21, 1938.)

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"In the State of Washington electric fence has ended night raids by elk on haystacks." (Nicholson, 1937, p. 22.)

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"This Department has done some experimental work with electric fences and has assisted some farmers with their installation to prevent damage.

"Battery units were first used by the Game Department to keep elk from haystacks in the vicinity of Yakima, Washington. Two charged wires were used, evenly spaced on five foot posts (5 feet above the ground) with the fence placed so close to the stack that the elk could not jump over, and far enough away so that to reach through the fence for hay made it necessary for the animals to touch the wires.

"These fences were successful as long as the snow was damp and weather conditions were comparatively mild. But with sub-zero weather and dry snow the fence was of little value in stopping the elk. Dry snow insulates the feet of the elk so that there was no flow of current through to the ground.

"The fences were somewhat more successful when grounded wires were stretched between the charged wires causing the elk to receive a shock when touching two wires at the same time. This fence kept small bands of elk out quite successfully, but with the larger, more persistent herds, it was not so successful, as one elk would tear out a piece of the fence when it received the electric shock and then other animals would go in through the break in the fence. The baiting of the charged wires with small bundles of hay improved the efficiency of the fence because it delivered the shock direct to the sensitive nose of the animal.

"Four-barbed hog wire was used on most fences as it was most efficient, penetrating the heavy coats of the animals.

"On one occasion during mild weather a band of more than 50 elk returned to a stack each night for a week without getting a bite of hay before they became discouraged.

"Our principal objection to the electric fence is the large amount of attention necessary to keep it in condition. Most farmers do not understand the

mechanism and will do nothing to repair the fence in case it is grounded or disconnected." (Burton Lauckhart, letter of May 3, 1938.)

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Experiments in controlling elk in Yellowstone National Park were inconclusive but these animals are evidently more difficult than deer to control. They are more likely to push against a fence with their bodies than to touch it with their noses. Probably a three-strand fence, 50 inches high, of barbed wire will be required. (Rudolf L. Grimm, Report of March 21, 1938.)

*Fishes*

The use of electricity (though not by a fence) in controlling gars and carp may be of interest to some readers. Experimental results are described in a paper by J. G. Burr, 1931, full reference to which is in the bibliography.

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Preventing fishes, especially fry, from going into irrigation ditches, canals, millraces and other dangerous watercourses has proved difficult by mechanical screening. Experimentation has produced electric fish stops, however, that are satisfactory in design and effect, and which are recommended by competent authority. See Literature Cited: McMillan, 1928.

*Livestock*

"We have had an electric fence controller at the Alabama Research Unit for more than a year. The only occasion on which an attempt was made to use it was early in the spring of 1937. It was placed in operation for the purpose of excluding hogs and pigs from a small area in a peanut field where some traps and nets were set for the purpose of capturing doves. In brief, the electric fence controller was not found practical for this use due to the great variation in the size and height of the animals. For effective results we found that it was necessary to use almost as many wires as if no electric current was being used.

"Since that time the controller has been used at the Black Belt Substation, Marion Junction, Alabama, for the purpose of keeping hogs, of uniform size, within temporary pastures. Very satisfactory results have been obtained when used in this manner." (Allen M. Pearson, letter of March 30, 1938.)

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"We have found this equipment effective, if properly handled, in excluding domestic livestock from game plantings, though *wild* hogs have given some trouble and will probably be difficult to control." (Stoddard, 1938, p. 18.)

*Rabbit*

"In the Far West, charged wires strung a few inches from the ground have been used to keep rabbits out of truck patches." (Nicholson, 1937, p. 72.)

*Raccoon*

"Our use of this equipment has been in connection with protecting game birds in moderate-sized enclosures from fence-climbing predators. During two different years, we attempted to hold several female grouse, each with a brood of chicks, in open enclosures, about two-thirds of the area of which was within a dense woodlot. In each case, however, in spite of a 6-foot fence of $\frac{3}{4}$-inch mesh poultry netting, buried 6 inches in the ground, the birds were destroyed by predators, first among which was the raccoon.

"In a following trial, using the same enclosure, but with a single strand of barbed wire strung about 4 to 6 inches above the fence and connected to the electric unit, the loss from predation was almost entirely eliminated. In this case, the ground connection was through the fence itself, the lower portion of which was buried." New York. (Robert W. Darrow, letter of March 24, 1938.)

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"We first made use of electrical fence about two years ago in retaining the 1,500 raccoons which we have at the Milan Raccoon Farms, operated by the Ohio Division of Conservation.

"During the reproduction season the raccoons are confined to small breeding pens, about 10×8, or in the case of the new type hutches, 3×3×10 which are raised above the ground and the animals supported on wire. Our research has shown that raccoons, like many other species, differ greatly in stocking value and that a period of hardening greatly increases that value. In fact it is absolutely necessary for young raccoons to undergo a period of muscular development and conditioning and training by being permitted to run in large pens and climb trees for some weeks before they are released.

"We have a series of pens of about two acres each which are used on a rotational basis. These pens are surrounded with a heavy guard fence 10 feet high. This of course would be of no value in retaining raccoons, as they could readily climb over it. To prevent this the lower part of the fence is protected by a band of tin roofing, 3 to 5 feet wide. This when properly erected is so smooth that raccoons cannot climb up it. Every joint and rivet is a potential toe hold, however, and one tiny niche gives enough purchase to enable a muscular raccoon to jump above the band of smooth tin and escape over the fence. Our raccoons have also proved themselves efficient in figure building, like gymnasts, that is, they will climb up on each others' shoulders, two to four deep, and walk out over this living bridge.

"It seemed very desirable to have an electrical fence in conjunction with the smooth metal to keep the animals from bunching up and going over it or escaping in any other way. Upon trial such a fence has proved very effective. One or two strands of wire have been used. They are held by insulators about three inches inside the fence. These strands have been placed at varying heights from 6 inches to 2 feet above the ground. About the only difficulty has been shorting on a few wet nights, or during storms when trees killed by too much raccoon climbing, fell across the fence. A relatively low charge is sufficient and no raccoon has been electrocuted.

"Individuals vary greatly, however, in reaction to the electrical wire. Some will come back to it again and again and absorb a great amount of punishment, but most learn by the first experience and stay away from the wire thereafter.

"Raccoons recently moved and in a highly excited condition are more likely to be stubborn in their attempts to get past the wire. Young raccoons learn more quickly than the adults. Occasionally an old female is difficult to educate and may persist in taking the shocks for several days. In fact, on a few occasions, old females stimulated by con-

tacting the wire actually used it as a stepping stone and made a phenomenal leap from it to the unprotected fence above. Escapes are the exception, however, and as these large pens are used mostly for young raccoons, they have proved very satisfactory." (Lawrence E. Hicks, Report of April 8, 1938.)

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On a farm near Oconomowoc, Wisconsin, where Dr. Malcolm Rogers has been raising Canada geese, pheasants, and ducks of various kinds, he was harassed for years by raccoons and other animals breaking into enclosures, stealing eggs, and killing young birds. Installation of electric fence as shown in Plate 2 in 1935 was so successful as a preventive that not a single animal has since been found inside the enclosures. (C. P. Fox, letter of May 6, 1938.)

### SUGGESTIONS

Why not replace pole traps with electrified perches? This would require a two-way circuit but would in the end be more economical than the installation and operation of pole traps and a great deal better for birds, many of which killed by pole traps are innocent of the damage the traps are intended to prevent.

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In places where deer may receive cuts from existing fences or become entangled in them, the animals may be trained to keep away from the fences by installation of an electrified single wire.

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Use of a single electric wire at the bottom of a fence may obviate the necessity of burying in the ground the lower part of a "vermin" repelling fence.

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Electrified wiring at the threshold should prevent predators from entering poultry houses at night.

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"For several years we have used electric prod poles to induce stubborn bears to move from bear traps into shipping crates. Bears are very susceptible to electric shocks and move with all the speed at their command when touched with one of these prodding devices." (Maynard Barrows, letter of November 26, 1937.) It should be noted that such prods have been used for many years as an aid in loading livestock into cattle cars.

### OBJECTIONS

Crude outfits drawing current from high-tension power lines have, in a few cases, started fires, killed stock, or killed people. Such equipment must be entirely abolished.

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It is said that in California no electric fence controller on the market meets the requirements of the State Industrial Accident Commission. An engineer of that Commission writing of the use of electric fence as an economy measure on farms says, "Since this saving in dollars is likely to be secured at the appalling cost of a human life, it is unbelievable that anyone who knows of the hazards of the electric fence would be willing to take such chances for the saving of many dollars." (Frank A. Short, "Electric Fences Save Money but Increase Deaths," *Electrical West*, 79(6), December 1937, p. 47.)

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It is reported that a young hunter was killed by an electric fence that conformed to the regulations of Oregon,

the first State to pass a law on this subject. "The safe limits of electric discharges in terms of measurable characteristics are not known but are under investigation by a number of agencies. Opinion among investigators seems to indicate a necessity for determining the more important of these limits before a definition of a safe electric fence can be given.

"Connection to an alternating current source, such as a lighting circuit, through any kind of homemade or amateur-designed equipment seems to be especially hazardous and even well-trained engineers can not as yet definitely predict the characteristics of an electric current applied to a long fence line under varying weather conditions. Engineers, physicists, and physiologists are working toward a solution of present difficulties and it is hoped that in the near future definite recommendations can be made regarding the construction of electric fence equipment." (S. H. McCrory, Chief of Bureau of Agricultural Engineering, letter of April 18, 1938.)

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When animal overpopulations are concerned, the remedy lies not in local control by fencing but in reduction of population density. (Gerstell, 1938, p. 32.)

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The necessity of keeping grasses and weeds from touching the wires puts further emphasis on clean farming—already a bane to wildlife. This phase of the matter is more fully treated in the following statement by Ralph T. King:

"Electric fences were becoming quite popular in a number of regions in Minnesota, particularly in those of intensive farming. As you know, the farm lands of southern Minnesota are flat to gently rolling and almost every square foot of each farm can be cultivated. Until the advent of the electric fence, a certain proportion of each farm was left uncultivated because of the inability of the farmers to get their machinery right up to the barbed wire and woven wire fences. These fence rows of several feet in width supported a fairly rank growth of grass and weeds and sometimes possessed in addition, shrubs and vines. Although they were not ideal nesting cover they did provide for a certain amount of nesting, furnished some feed for wildlife, some winter cover, and most important of all, the lanes of cover which small mammals and upland game birds could use in traveling from feeding areas to cover or from watering places to cover. They were also extremely valuable for song and insectivorous birds.

"Since the adoption of the electric fences the farmer has been enabled to cultivate every foot of this previously relatively desirable cover. He not only can drive his horse and machinery right up to the fence line, by switching off the current during working periods, but worse than that, from the wildlife point of view, he can move the fence frequently during the year to allow for more complete cultivation of what would otherwise be a fence row, and for utilization of the entire area by livestock, And most of these farmers graze their livestock in their cornfields after the crop is harvested and in their winter wheatfields for a period each fall. The use of these fences on some farms has eliminated the last vestige of undisturbed cover and natural foods available for any species of wildlife.

"I have no reason as yet to believe that the fences are directly harmful to wild animals, but I have good reason to believe that if they are adopted on any wide scale, wildlife on farms will find it increasingly difficult to nest, protect themselves from winter storms, travel with any degree of safety from one location to another, and find food, except during those periods of the year when ripened grains are available in the field."

### CAUTIONS

In the present state of development of electric fences, care must be the watchword. To repeat, it will be safer for wildlife managers to use only battery equipment of limited power.

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In some States there are legal requirements as to line fences; these should not be electrified, therefore, until proper inquiry has been made. Even if legal, charging of line fences (especially those along roads) with electricity may be undesirable. Wisconsin requires that electric fences be plainly labelled every 200 feet.

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For safety's sake it would not be "at all amiss to place the use of electric fencing for any and all purposes under strict state regulation." (Gerstell, 1938, p. 32.)

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Admitting local and temporary utility of electrification of fencing, "the principle probably never should be used in wildlife work to the extent to which many laymen, unaware of its limitations and dangers, are now inclined to propose." (Gerstell, 1938, p. 32.)

### WHAT TO DO IN CASE OF SEVERE ELECTRICAL SHOCK

If possible break the current by opening the nearest switch or by cutting the wire with an axe or hatchet with a dry wooden handle, carefully avoiding other contact with it. If neither of these things can be done quickly, free the victim from the wires, using dry non-conductors (rubber, rope, clothing, wood) in moving either the victim or the wires. The rescuer should stand on a dry board if obtainable, or if not, on a folded coat, newspaper, or other insulating material.

Begin artificial respiration at once, removing any loose objects from the mouth, placing the victim face down, the head turned to one side, and alternately apply and release pressure over the lower ribs, using about 2 seconds for each phase, or timing the movements with the resuscitator's own deep breathing. Continue until natural breathing has been restored or until rigor mortis sets in. Do not give up easily as resuscitation has been accomplished after very protracted effort (8 hours). When breathing has been established, loosen any clothing that might interfere with it. Keep patient lying down but wrap in anything available to keep him warm. Watch breathing and return to artificial respiration at the first sign of need. In severe weather, if necessary to move the victim to shelter, place him on a firm support (plank, door, floor of vehicle) and apply artificial respiration continually during the move.

When breathing is fully restored, stimulants may be given, but now is the time to take the patient to a doctor or bring a doctor to him—something to arrange for from the first if an extra

person is available to perform the errand.

For fuller accounts of resuscitative procedure, consult the papers by Foster and Maclachlan cited in the bibliography.

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# STUDIES ON THE BLOOD OF WHITE-TAILED DEER

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The role played by disease in affecting wild animal populations is still relatively little known. In the past there was a general idea that wild species suffer very little from disease. As information accumulated on the wide fluctuations occurring at intervals in the populations of certain species, the hypothesis began to be advanced that they may be due to disease. The history of disease epidemics in man strongly suggested that a similar factor was operating to produce the enormous losses involved in animal fluctuations. Since populations are of great importance in animal husbandry, knowledge of any factor tending to change those of wild species is of value to wildlife managers.

The interrelation of certain human diseases and those of animals is reasonably well understood in many instances. The connection between man and wild animals in tularemia and other diseases is a matter of record. There are diseases affecting man alone (e.g. typhoid fever) and others peculiar to certain animals as infectious papillomatosis ("horns") of rabbits. In those diseases common to several species including man there tends to be a similarity in symptoms and in pathology although this is not always true. The following discussion deals with a condition in a game animal which in one aspect resembles a rather serious disease in man.

Since 1910 when Herrick (1) described elongated and sickleshaped cells in a case of severe anemia in a Negro, a considerable literature has accumulated on the subject of sickle-cell anemia in man. For a time it was thought that this condition was confined to negroes and that it was always associated with anemia. It is now known, however, that apparently healthy people of both the Negro and Caucasian races may have sickle cells in their blood. Surveys show an incidence of about 6%.

O'Roke (2) has recently described a comparable condition in deer, mainly from young animals found dead in winter yards in the Lower Peninsula of Michigan. His principal conclusion was that it might be a definite, if obscure, factor in the heavy losses among deer in Michigan observed during the past few years. He ventured the opinion also that the condition may be hereditary, a suggestion based on the fact that it was not revealed in a large number of examinations of a captive and rather highly inbred deer herd.

During the past two years efforts have been made by the Game Division of the Michigan Department of Conservation further to investigate the situation. Observations were made on numerous captive animals and studies were carried on of blood smears from animals found dead in the wild and from deer shot by hunters.

Red blood-cell counts and hemoglobin determinations were made at intervals from about twenty animals. Sickle cells were found in blood smears taken from a few young fawns, which were later periodically subjected to blood examinations. These animals have been under observation for the past two

years to determine if possible any correlation of blood characteristics with abnormalities in health. During the course of feeding experiments with other deer, blood samples were collected from a number of animals at about five-week intervals through the fall, winter and spring of 1936–37. The serum was analyzed for its calcium, phosphorus, and magnesium content.

During the study, autopsies were performed on about sixty animals and numerous inspections of dressed carcasses were made through two hunting seasons. Some of the animals, which at one time or another have shown sickle cells in their blood, were among those autopsied.

Animals dying under natural conditions in the deer-yards were not available for examination in any number, as due to lack of snow during the winter of 1936–37 the deer did not yard to any extent in Michigan except in the western part of the Upper Peninsula. In that area a number of dead animals were found in over-browsed yards. No unexplained mortalities were reported elsewhere in the state and for that reason the annual "dead deer" drives by the CCC were not held in the greater part of the deer range.

While it is apparent that erythrocytes of white-tailed deer exhibit a type of sickling, it does not present exactly the same characteristics as described for man. Its occurrence was observed independently by Coburn (3) of this laboratory coincidently with the observations of O'Roke. The long filaments attached at the extremities of the sickle cell as seen in human blood were not observed. The final form was a long narrow crescent. Before attaining the crescent shape the cells assumed a variety of bizarre forms. Macrocytes, microcytes, stellate cells, rod cells, and other shapes were seen in the counting chamber of the haemocytometer and in even promptly fixed smears.

Sickling seems to occur more frequently in deer than in man. O'Roke reported an occurrence of 8%, and a marked degree of sickling was noted in erythrocytes of about 12% of the animals examined during the present investigation. Many less developed cases were found that are not included in this total.

No reversal from sickle cells back to normal forms as reported by Huck (4) or Hahn and Gillespie (5) was noted.

Progressive development of the sickle forms in blood samples was apparent. The abnormal cells were usually noted in small numbers (1%–8%) in quickly fixed smears or in the counting chamber of the haemocytometer. This was true in samples of blood freely flowing from an ear incision. In fresh citrated samples more sickles could be seen. After such samples had stood for 24 hours it was not uncommon to find that almost all the cells had assumed the sickle form. In smears made from dead animals the same changes were apparent and they were observed in the blood of dead captive animals from which samples had been taken while the deer were alive. Great variations were seen in the samples in which sickling had developed to a marked degree, the percentage of cells exhibiting the phenomenon running from 25% to 95%.

There seemed to be no distinct correlation between the poikilocytic tendency and the health of captive animals as indicated by daily food consumption

and weight. Numerous red blood cell counts and hemoglobin determinations gave no indications of an associated anemia so common with this condition in man. Data as to the calcium, magnesium, and phosphorus content of the blood serum did not bring to light appreciable variations. Some of the animals studied were restricted to deficient diets, designed to duplicate as nearly as possible the types of foods obtained by deer under the severe conditions of winter yarding and in over-browsed areas. It is under these conditions that heavy winter losses of Michigan deer have occurred in recent years. Studies on the blood of these experimental animals did not show any definite correlation between the presence of the sickling phenomenon and mortality. Autopsy findings also were in general inconclusive. Study of bone marrow sections indicated that there was very little if any preformation of sickle cells in the haematopoietic tissue.

The picture of the situation thus is sketchy. On present information the sickling phenomenon in the blood of deer does not appear to be a disease in the ordinary sense of that word. It may more properly be considered as a physiological characteristic of the blood of certain deer. O'Roke's idea that it may be a hereditary condition is reasonable, since he did not find it in a captive herd which originated from six animals.

The facts gathered by the Game Division on deer mortality in Michigan emphasize the great importance of nutrition. Given a fairly satisfactory food supply the white-tailed deer is a remarkably healthy animal. In Michigan at least the species seems to be quite free from the infectious diseases so harmful to domestic ungulates, and apparently tolerates reasonably well most of its native parasites. To date no cyclic fluctuations in populations comparable to those of hares or grouse have been recorded. Conclusions from the sickle-cell studies as well as from other disease investigations point to management procedures, especially in maintaining the winter food supply as the vital factors in conserving the white-tailed deer in Michigan.

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# SICKLE CELLS IN THE BLOOD OF WESTERN DEER[1]

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Sickle-cell anemia of deer as it has been called has been reported in Michigan and California. It was first thought to be an active form of anemia, but subsequent accounts seem to indicate that it generally exists in a latent form.

Sickle-cell anemia in humans was first reported by Herrick (1). It was described as a hereditary and familial disease present and recognizable in very early infancy, and peculiar to the negro race. It was thought that there is some congenital defect of the red corpuscles which renders them more susceptible to hemolytic toxins and to phagocytosis. The red cells, however, show normal resistance, and in some cases increased resistance, to hypotonic salt solutions.

O'Roke (2) reported 14 sickle-cell cases in 178 white-tailed deer examined in Michigan, over a period of eight years.

The condition was first found in Oregon during the summer of 1938, while examining a Columbian black-tailed deer at the Department of Veterinary Medicine of the State Agricultural College.

This deer, a castrated male, had been raised on a deer farm in southwestern Oregon. The owner had been rearing deer on this farm for five years and at that time had about 55 deer, including Columbian black-tailed deer (*Odocoileus c. columbianus*), mule deer (*Odocoileus hemionus macrotis*), a few black-tailed×mule deer crosses, and one white-tailed deer (*Odocoileus virginianus*).

An autopsy of the deer revealed no gross pathology, other than myiasis, a few maggots being found in a pouch on the wall of the pharynx. The owner suspected lungworms, and claimed to have found lungworms in some of the deer that had died earlier in the summer. He complained, too, of an unthrifty condition of the entire herd.

Examination of the herd revealed a generally poor condition. The deer had been kept in a low pasture along a creek during the early part of the summer, and it is possible that they had been infested with lungworms. There had been much coughing and several had died. Their condition improved after they were moved to higher ground.

Blood smears were made from four black-tailed deer, four mule deer, and one crossbred fawn sired by a mule deer buck out of a black-tailed doe. A single smear was made also from one of two black-tailed does kept on a ranch three miles distant. These deer seemed to be in excellent condition, and had at no time come in contact with the large herd. Later, additional smears were made, one from a black-tailed fawn, 190 miles from the herd, and another from a mule deer from eastern Oregon.

All of the smears from the black-tailed deer showed poikylocytosis, many of the corpuscles being sickle- or crescent-shaped. No sickle cells were

[1] Published as technical paper No. 297 with the approval of the Director of the Oregon State College Experiment Station. Contribution from the Department of Veterinary Medicine.

noted on any of the smears made from the mule deer or the crossbred fawn.

Due to the small number of specimens examined, it is impossible to tell whether there is any correlation between the number of sickle cells and the condition of the animals.

Supravital stains were made of blood taken from a tame black-tailed doe, on the supposition that they might give slightly better definition of the red cells than a moist cover slip preparation. They were examined within a few minutes, and the sickling was about as prevalent as noted on dry smears treated with Wright's stain, indicating that the sickling was not due to the staining methods.

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# AN ANALYSIS OF HUNTING RECORDS FOR THE PRAIRIE FARM PROJECT, SAGINAW COUNTY, MICHIGAN, 1937

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The Prairie Farm is located in the central part of Saginaw County, Michigan (Towns 10–11 North, and Ranges 3–4 East, Fig. 1). It consists of 8,956 acres of flat land isolated by the Flint and Shiawassee Rivers and by a system of large canals and dikes.[1] The canals, which enclose all except 555 acres of the project, are several feet deep and 20 to 30 feet wide. The large dikes, approximately 12 feet high and 60 feet wide, prevent the inundation of the area when the two rivers are at flood stage. Extensions of the canals and dikes converge within the area and divide the farm into three irregular blocks of land. A network of secondary canals and ditches has been projected along the section and forty lines to facilitate the drainage of the cultivated fields. The water table can be regulated by pumping into the Flint River.

The soil is basically lake-bed clay with a surface layer of muck which varies from one to four feet in depth. Repeated fires have consumed much of the humus in some of the fields toward the east side of the project. Not more than 10% of the cultivated area however has burned over in the last 20 years.

A considerable acreage has never been brought under cultivation, although the major portion of the land has been cleared of timber. Approximately 4,000 acres are under cultivation, 2,000 acres are utilized for pasture, and 400 acres are in wood lots. The balance, nearly 2,600 acres, is waste land which has grown up to brush (*Salix, Populus, Cornus,* etc.) and rank weeds. Burdock (*Arctium*) is abundant on the dikes; bull thistles (*Cirsium*) predominate in many of the uncultivated fields; smart weed (*Polygonum*), pigweed (*Amaranthus*), beggar ticks (*Bidens*), nettles (*Urtica*), and many other weeds and sedges flourish generally. (Plates 3 and 4 indicate the general appearance of the farm.)

Barley, mint, and sugar beets are the principal crops, but approximately 325 acres were planted to corn in 1937. The corn fields were widely distributed over the area, and none of them exceeded 40 acres in size. Waste grain was plentiful in some of the fields, and shocks were left out all winter in others. Several large packs of pheasants made their winter headquarters in weedy cover adjacent to these fields.

So far as known, the Prairie Farm has never been entirely closed to hunting, but the hunting was much restricted for three seasons preceding 1937. The following excerpt from a letter written by Merton L. Wright, manager of the Prairie Farm for the Farm Security Administration, recounts the recent history of hunting in the area.

"The hunting in 1936 was not taken care of by the Farm Security Adminis-

[1] Only 8,401 acres lie within the boundaries of the canals and dikes. No attempt was made to control hunting on the 555 acres outside the limits of the dikes.

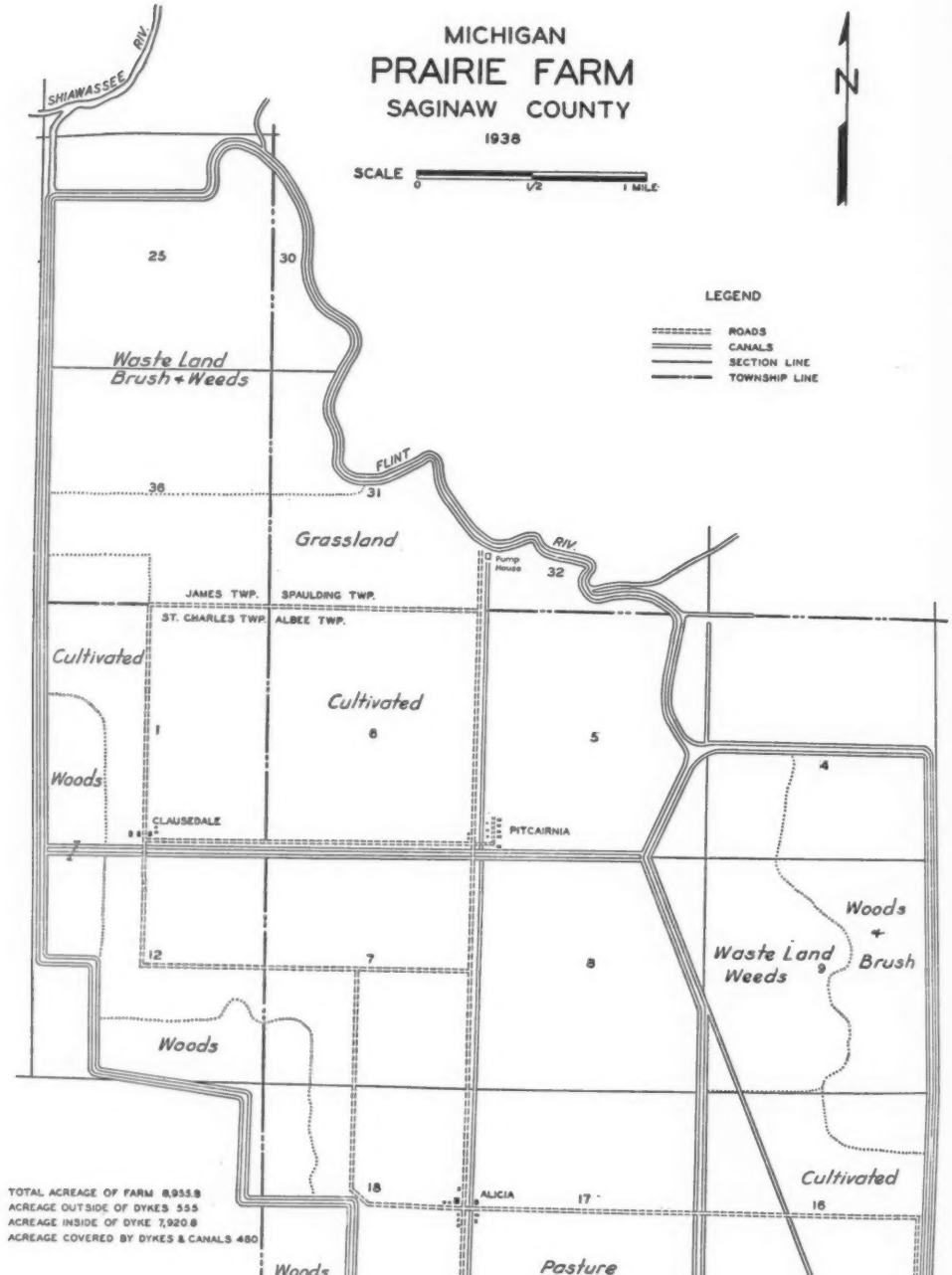
MICHIGAN
PRAIRIE FARM
SAGINAW COUNTY
1938
SCALE
0
1/2
1 MILE
N
SHIAWASSEE RIV.
LEGEND
ROADS
CANALS
SECTION LINE
TOWNSHIP LINE
25
30
Waste Land
Brush + Weeds
FLINT RIV.
36
31
Grassland
Pump House
32
JAMES TWP.
SPAULDING TWP.
ST. CHARLES TWP.
ALBEE TWP.
Cultivated
Cultivated
1
6
5
4
Woods
CLAUSEDALE
PITCAIRNIA
Woods
+
Brush
Waste Land
Weeds
12
7
8
9
Woods
TOTAL ACREAGE OF FARM 8,935.8
ACREAGE OUTSIDE OF DYKES 555
ACREAGE INSIDE OF DYKE 7,920.8
ACREAGE COVERED BY DYKES & CANALS 480
18
ALICIA
17
16
Cultivated
Woods
Pasture

Figure 1

tration. We had not acquired title to the land, and the 1936 pheasant season was taken care of by the Sunrise Co-operative Farm Community. They made a charge for hunting of $10.00 for the season, $5.00 for opening day, $2.00 for Sundays or Saturdays, and $1.00 for other days. I estimate that they had not over 100 hunters on the place for 1936. I am also estimating that they possibly took in $75.00 income. We have no record of the number of birds taken in 1936, but I would guess that this number was around 100 birds. In the previous two years before 1936 it is reported that the Sunrise conducted the hunting here much the same as they did in 1936. To my knowledge I do not believe that the Farm has ever been entirely closed to pheasant hunting."

In order to promote better public relations, the Farm Security Administration decided to open the Prairie Farm to public hunting, but some measure of control was obviously necessary. The Michigan Department of Conservation was invited to assist in working out a plan. The Game Division agreed to supply posters and tickets similar to those used on the Cooperative Hunting Exchanges and to assist in the registration of hunters.

Only two roads enter the Prairie Farm which is otherwise accessible only by boat. A few hunters may have entered the area without registering, but errors in the data from this cause are believed to be insignificant. At the time of registration the hunters were asked to record the pheasants and other game seen during the day, and to guard against fire and accidents. A conservation officer was stationed at headquarters to check game bags and prevent hunters from leaving the area without the formality of checking out. Records of the occurrence and kill of game were handled by two men from the Game Division.

### ABUNDANCE OF GAME SPECIES

Pheasants are by far the most abundant game species inhabiting the Prairie Farm. We do not know how many pheasants actually were present on the farm at the opening of the hunting season, but we can make a fairly accurate estimate. Since 616 cock birds were killed[2] and since the sight records (Table 1) indicated that the sex ratio was approximately 2 hens to 1 cock, we find that a minimum of 1,848 pheasants inhabited the area. But, since it is unlikely that more than half of the cocks in the area were killed, the population would be 3,696 birds, which is equivalent to 282 pheasants per square mile or 1 for each 2.2 acres.

A comparison of the sight records and kill on the first three and last three days of the hunting season seems to justify the assumption that only one-half of the cocks in the area were killed. Approximately two-thirds as many cocks were seen per gun hour on the last 3 days as on the first 3 days, and more than one-half as many cocks were killed per gun hour on the last 3 days as on the first 3 days (Table 2).

Circumstances have prevented a winter census of the pheasant population on the Prairie Farm. Surveys of the area made in January and April however indicate that hens are numerous

[2] Michigan game laws prohibit the shooting of female pheasants; cocks may be shot between October 15 and 31, inclusive; the daily bag limit is 2; and the seasonal limit 6.

and cocks plentiful. There is no evidence of overshooting.

Prairie chickens were seen by several hunters, but no one observed more than 8 birds in a flock, and it is doubtful if the actual population exceeded that figure.

Only one woodcock was reported, but 34 jacksnipe were recorded as "seen" and 2 were killed.

TABLE 1

DATA RELATIVE TO THE SIGHT RECORDS AND KILL OF PHEASANTS AND RABBITS ON THE PRAIRIE FARM

1937

| Date | Hunters per Day | Gun Hours per Day | Game Seen | | | Game Shot | | Number of Dogs used |
|---|---|---|---|---|---|---|---|---|
| | | | Pheasants Hens | Pheasants Cocks | Cotton-tails | Pheasants Cocks | Cotton-tails | |
| Oct. 15 | 192 | 782 | 566 | 456 | 12 | 117 | 12 | 71 |
| 16 | 303 | 1,358½ | 640 | 472 | 21 | 111 | 10 | 91 |
| 17 (Sunday) | 389 | 1,527 | 778 | 420 | 46 | 94 | 8 | 101 |
| 18 (rain) | 6 | 18½ | 20 | 6 | 0 | 3 | 0 | 1 |
| 19 | 48 | 116 | 153 | 63 | 2 | 8 | 1 | 21 |
| 20 | 31 | 86½ | 84 | 61 | 8 | 8 | 0 | 12 |
| 21 | 63 | 223 | 264 | 164 | 8 | 23 | 2 | 36 |
| 22 | 106 | 304½ | 412 | 167 | 9 | 17 | 2 | 39 |
| 23 | 222 | 753 | 502 | 243 | 27 | 50 | 6 | 79 |
| 24 (Sunday) | 239 | 907 | 643 | 236 | 43 | 57 | 7 | 86 |
| 25 | 18 | 52½ | 56 | 26 | 3 | 7 | 1 | 10 |
| 26 | 22 | 70 | 94 | 29 | 1 | 3 | 0 | 11 |
| 27 | 57 | 183½ | 169 | 56 | 11 | 25 | 4 | 28 |
| 28 | 40 | 96 | 144 | 75 | 5 | 5 | 1 | 20 |
| 29 | 47 | 128 | 111 | 55 | 3 | 9 | 1 | 22 |
| 30 | 162 | 619½ | 502 | 196 | 19 | 27 | 6 | 76 |
| 31 (Sunday) | 236 | 942½ | 609 | 214 | 34 | 52 | 10 | 107 |
| Totals | 2,181 | 8,168 | 5,747 | 2,939 | 252 | 616 | 71 | 811 |

Nine ruffed grouse were flushed in the wooded areas during the season, but none were killed.

Game and fur-bearing mammals occur on the Prairie Farm in normal numbers. The total number of cottontails reported (252) and killed (71) by the hunters during the season is lower

TABLE 2

COMPARISON OF PHEASANT SIGHT RECORDS AND KILL ON THE FIRST THREE AND THE LAST THREE DAYS OF THE SEASON

| Date | Number of Hunters | Total Gun-Hours | Hens Seen | Cocks Seen | Cocks Seen per Gun Hour | Cocks Killed | Cocks Killed per Gun Hour |
|---|---|---|---|---|---|---|---|
| October 15, 16, 17 | 883 | 3,568 | 1,992 | 1,252 | .35 | 323 | .090 |
| October 29, 30, 31 | 445 | 1,689 | 1,222 | 443 | .26 | 88 | .052 |

Ducks were seen frequently in small flocks, but geese were reported by only one hunter who probably saw one or two large flocks in the air.

(*Upper*)—Dike and canal on south boundary of Prairie Farm.

(*Lower*)—View of a cultivated field and a secondary drainage ditch. Farm Security Administration Headquarters in the background.

(*Upper*)—Burdock made hunting difficult on the dikes and in many fields.
(*Lower*)—Stubble fields and ditch banks constituted good hunting range.

than might be expected on so large an area (Table 1). The rabbit population on the Farm very likely is higher than these figures would indicate; first, because the cover was so tall and dense over much of the area that rabbits could easily escape without being seen; and second, because the majority of hunters were seeking pheasants and gave other game scant attention.

## ANALYSIS OF DATA

A daily average of 128 individuals hunted on the Prairie Farm during the 17 day pheasant season, which is equivalent to a daily average of 9 hunters per square mile. Some sections of the Prairie Farm were much more heavily hunted than others. The vegetation was so tall and dense on much of the waste land that hunters found it difficult to move about or to work their dogs. Consequently, many hunters avoided the waste land at the north end of the project and concentrated in the cultivated fields and more easily accessible territory adjacent to the roads.

On the first Sunday of the hunting season when the majority of Michigan's 300,000 pheasant hunters were in the field, the unit hunting pressure on the Prairie Farm was twice as great as for the State as a whole. Since there are about 12,000,000 acres of pheasant range in Michigan,[3] the hunting pressure must have been approximately 1 hunter to each 40 acres while on the Prairie Farm it was 1 to each 21.6 acres.

There are other sections of the Lower Peninsula where the hunting pressure may exceed even this ratio; it is known to be very heavy in the vicinity of most of the larger cities and in the "Thumb" region southeast of Saginaw Bay.

A total of 8,168 gun hours were spent in the field. The average number of pheasants killed per gun hour was .075, and the average number of cottontails killed per gun hour .008. In other words, almost 14 hours of hunting were expended in bagging each pheasant, and 125 hours in bagging each rabbit. These averages are very low and seem to indicate that the hunting was either very poor or very difficult. In view of the relatively high kill of pheasants, we are justified in assuming that the latter was the case.

The total kill of 616 cock pheasants is equivalent to 47+ cocks per square mile or 1 cock for each 13.6 acres.

The actual time spent in the field by the different hunters averaged 3.7+ hours per day for the season, which is less than might be expected.

The daily sight records of pheasants should have provided a good basis for calculating the sex ratio, but the records indicate that the men who recorded the data failed to make certain whether the hunters included their kill among the cocks recorded as seen, or whether they had excluded their kill in reporting "cocks seen."

Assuming that the hunters in reporting the number of cocks seen did include the birds which they killed, we find the sex ratio would equal 1 cock to 1.95 hens, but if they excluded their kill in reporting "cocks seen," the sex ratio would equal 1 cock to 1.61 hens.

For the sake of accuracy it is unfortunate that this difficulty was not fore-

[3] Veatch, J. O., "Agricultural Land Classification and Land Types of Michigan." Special Bulletin No. 231, Michigan State College of Agriculture and Applied Science. April 1933.

seen, but the fact remains that a sex ratio of approximately 1 to 2 is exceptionally good. This favorable sex ratio may be attributed to the fact that the hunting on the project had been restricted for the three years prior to 1937. English[4] found that the pheasant

TABLE 3

RECORD OF DOGS USED BY HUNTERS, PRAIRIE FARM

1937

| | | |
|---|---|---|
| Hounds | | 305 |
| | Basset | 4 |
| | Beagle | 136 |
| | Black and Tan | 33 |
| | Blue Tick | 11 |
| | Red Bone | 2 |
| | Walker | 9 |
| | Unclassified | 110 |
| Spaniels | | 199 |
| | Springer | 131 |
| | Cocker | 50 |
| | Water | 10 |
| | Unclassified | 8 |
| Setters | | 171 |
| | English | 98 |
| | Irish | 28 |
| | Unclassified | 45 |
| Pointers | | 23 |
| Mixed and Miscellaneous Breeds | | 113 |
| Total | | 811 |

sex ratio in Williamston Township (Ingham County) was 1 cock to 5 hens. Many recent observations by our conservation officers, staff members, and other competent observers indicate that a sex ratio of about 1 to 4 prevails genally throughout Michigan's pheasant range, with local areas where the discrepancy between the numbers of cocks and hens is as much as 1 to 7. The conservation officer in Tuscola County kept records of the occurrence of hens and cocks at his feeding stations last winter. His report indicates a sex ratio of 1 cock to 3 hens despite the fact that Tuscola County is located in the "Thumb" region where the hunting pressure is very heavy. Observations in the State as a whole, however, do not indicate that the pheasant sex ratio is seriously out of balance.

The men at the checking stations attempted to record as much data as possible concerning the dogs brought into the area by the different hunting parties. This data has been condensed and tabulated (Table 3). We were surprised to find that hounds led all other varieties and that beagles were as popular as springer spaniels.

Sportsmen might well note the fact that the 75% of the hunters who used dogs bagged 87% of the pheasants.

## SUMMARY

The area on which the survey was made consists of 8,401 acres.

The survey involved 2,181 man days of hunting, and a total of 8,168 gun hours of hunting.

Average number of pheasants killed per gun hour was .075.

Average number of hunters per day was 128.

Daily average of hunters per square mile was 9.

Hunting pressure on the Prairie Farm was twice as great as for the State as a whole on the first Sunday of the hunting season.

Total kill of cock pheasants was equivalent to 47+ cocks per square mile and to 1 cock for each 13.6 acres.

A comparison of the cock pheasants killed per gun hour on the first three and last three days of the season indicates that less than half of the cocks

[4] English, Dr. P. F., "Causes of Pheasant Mortality in Michigan." Unpublished manuscript, 1935.

were killed, and if only that proportion was killed the total pheasant population of the Prairie Farm must have equalled 3,696 birds, or 1 pheasant for each 2.2 acres.

Sight records indicated that the ratio of cock pheasants to hens was not greater than 1 to 2.

A total of 811 dogs were used by the hunters during the season.

75% of the hunters used dogs, and they bagged 87% of the pheasants.

Observations during the winter indicate that cock pheasants are still plentiful and that hens are numerous on the Prairie Farm.

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# PHEASANTS ACTIVATED BY NIGHT-LIGHTING RETURN TO NORMAL NESTING[1]

*Thomas Hume Bissonnette and Albert George Csech*

Previous studies (Bissonnette and Csech, 1936a, b, 1937, 1938a, b) have shown that ring-neck pheasants (*Phasianus colchicus torquatus*) can be induced to lay from January 15 onward by night-lighting begun on December 16, with high production up to 105+ eggs per hen before June 29, but that not all of the birds are equally affected by the treatment. May 7th chicks have been induced to lay at 185 days of age from November 8 onward in their first year, with fertile eggs hatching on Christmas day. These Christmas chicks have laid eggs late in the following July without experimental lighting. Birds induced to lay fertile eggs by winter night-lighting paused for varying periods after return to normal daylength on April 1 and then laid infertile eggs at a slower rate.

An attempt has been made to learn whether pheasants of different varieties induced to produce eggs between January and March inclusive will nest and lay fertile eggs after return to normal days. If so they may be planted in the wild to produce and rear broods. This will permit a double use of the birds: (1) for production of many early fertile eggs under controlled conditions in February and March, and (2) for production and rearing of wild broods after liberation about April 1.

[1] Aided by grants from the National Research Council, Committee for Research in Problems of Sex, 1937–38, and by cooperation from the Connecticut State Department of Fish and Game.

## Material and Methods

Three groups of pheasants of different varieties, all first-year birds, were selected at random. Group 1 consisted of one cock and three hens of the blackneck (*Phasianus colchicus colchicus*); group 2 of one cock and three hens of the common ring-neck (*Phasianus colchicus torquatus*), all from eggs of night-lighted birds; and group 3 of one cock and five hens of the Mongolian variety (*Phasianus colchicus mongolicus*). These groups are in ascending order of egg-production in captivity at Shade Swamp Sanctuary, Mongolians being the earliest and most prolific layers.

Night-lighting was added to days normal for the season in outside pens, described before, commencing each evening at 4.30 o'clock; January 6–13, 1½ hours; 13–20, 2½ hours; 20–27, 3½ hours; January 27–February 3, 4½ hours; and from that date to April 3, 6 hours each night.

Controls consisted of the rest of the pheasants of each of the three subspecies at the sanctuary kept in larger pens without added lighting but with food and care otherwise the same. Trap-nesting was impossible, so the average numbers of eggs per bird per day of controls and lighted birds of each variety after laying began are taken as criteria of the results of the experimental lighting. Records of control birds were kept only from April 2 to April 21.

### OBSERVATIONS AND RESULTS

One hen from the group of ring-neck pheasants died on March 5 and was not replaced, leaving one cock and two hens in that group. One black-neck hen had her feet frozen in late January or early February, but she laid some eggs in spite of this handicap. Ring-necks began to lay on February 21, black-necks on the 24th, and Mongolians on the 28th. Their performances are recorded in Table 1.

TABLE 1

| | Group I Black-necks (3 hens) | | Group II Ring-necks (3 hens to March 5, 2 later) | | Group III Mongolians (5 hens) | | |
|---|---|---|---|---|---|---|---|
| Date | Eggs Daily | Total to date | Eggs Daily | Total to date | Eggs Daily | Total to date | Grand total |
| Feb. 21 | — | — | 1 | 1 | — | — | 1 |
| " 22 | — | — | 2 | 3 | — | — | 3 |
| " 23 | — | — | 1 | 4 | — | — | 4 |
| " 24 | 1 | 1 | 0 | 4 | — | — | 5 |
| " 25 | 0 | 1 | 2 | 6 | — | — | 7 |
| " 26 | 1 | 2 | 2 | 8 | — | — | 10 |
| " 27 | 0 | 2 | 2 | 10 | — | — | 12 |
| " 28 | 1 | 3 | 1 | 11 | 3 | 3 | 17 |
| Mar. 1 | 1 | 4 | 2 | 13 | 1 | 4 | 21 |
| " 2 | 1 | 5 | 1 | 14 | 2 | 6 | 25 |
| " 3 | 1 | 6 | 2 | 16 | 3 | 9 | 31 |
| " 4 | 2 | 8 | 2 | 18 | 3 | 12 | 38 |
| " 5 | 1 | 9 | 2 | 20 | 3 | 15 | 44 |
| " 6 | 2 | 11 | 1 | 21 | 3 | 18 | 50 |
| " 7 | 1 | 12 | 0 | 21 | 4 | 22 | 55 |
| " 8 | 1 | 13 | 0 | 21 | 3 | 25 | 59 |
| " 9 | 2 | 15 | 2 | 23 | 1 | 26 | 64 |
| " 10 | 2 | 17 | 2 | 25 | 3 | 29 | 71 |
| " 11 | 2 | 19 | 2 | 27 | 3 | 32 | 78 |
| " 12 | 2 | 21 | 1 | 28 | 4 | 36 | 85 |
| " 13 | 1 | 22 | 1 | 29 | 3 | 39 | 90 |
| " 14 | 2 | 24 | 1 | 30 | 4 | 43 | 97 |
| " 15 | 1 | 25 | 1 | 31 | 5 | 48 | 104 |
| " 16 | 2 | 27 | 2 | 33 | 4 | 52 | 112 |
| " 17 | 4 | 31 | 1 | 34 | 4 | 56 | 121 |
| " 18 | 1 | 32 | 1 | 35 | 3 | 59 | 126 |
| " 19 | 1 | 33 | 1 | 36 | 2 | 61 | 130 |
| " 20 | 1 | 34 | 1 | 37 | 3 | 64 | 135 |
| " 21 | 1 | 35 | 1 | 38 | 4 | 68 | 141 |
| " 22 | 2 | 37 | 1 | 39 | 2 | 70 | 146 |
| " 23 | 1 | 38 | 1 | 40 | 4 | 74 | 152 |
| " 24 | 1 | 39 | 1 | 41 | 3 | 77 | 157 |
| " 25 | 1 | 40 | 2 | 43 | 4 | 81 | 164 |
| " 26 | 2 | 42 | 1 | 44 | 3 | 84 | 170 |
| " 27 | 1 | 43 | 1 | 45 | 3 | 87 | 175 |
| " 28 | 1 | 44 | 1 | 46 | 4 | 91 | 181 |
| " 29 | 2 | 46 | 1 | 47 | 3 | 94 | 187 |
| " 30 | 2 | 48 | 2 | 49 | 2 | 96 | 193 |
| " 31 | 2 | 50 | 2 | 51 | 2 | 98 | 199 |
| Apr. 1 | 2 | 52 | 2 | 53 | 2 | 100 | 205 |
| " 2 | 2 | 54 | 2 | 55 | 1 | 101 | 210 |
| " 3 | 1 | 55 | 2 | 57 | 2 | 103 | 215 |

Eggs per hen per day after starting

0.470 for 39 days 0.5992 for 42 days 0.5884 for 35 days

Controls began to lay: Mongolians on April 2, ring-necks on April 6, and black-necks on the 7th. Their records of performance up to and including April 21 are given in Table 2. The production for four hens of each variety was 69, 38 and 29 eggs, respectively, earlier. Black-necks laid 18.3 eggs per bird in 39 days or 0.470 eggs per bird per day; ring-necks, 25.16 in 42 days or 0.5992 eggs per hen per day; Mongolians, 20.6 eggs per hen in 35 days, or 0.5884 eggs per hen per day. Controls laid: black-necks 29/4 or 7.25 eggs in

TABLE 2

| | Group I Black-necks (4 hens & 1 cock) | | *CONTROLS* Group II Ring-necks (4 hens & cock) | | Group III Mongolians (4 hens & cock) | | |
|---|---|---|---|---|---|---|---|
| Date | Eggs Daily | Total to date | Eggs Daily | Total to date | Eggs Daily | Total to date | Grand total |
| Apr. 2 | — | — | — | — | 2 | 2 | 2 |
| " 3 | — | — | — | — | 2 | 4 | 4 |
| " 4 | — | — | — | — | 2 | 6 | 6 |
| " 5 | — | — | — | — | 5 | 11 | 11 |
| " 6 | — | — | 1 | 1 | 3 | 14 | 15 |
| " 7 | 1 | 1 | 2 | 3 | 3 | 17 | 21 |
| " 8 | 1 | 2 | 1 | 4 | 3 | 20 | 26 |
| " 9 | 1 | 3 | 1 | 5 | 4 | 24 | 32 |
| " 10 | 1 | 4 | 1 | 6 | 4 | 28 | 38 |
| " 11 | 1 | 5 | 1 | 7 | 2 | 30 | 42 |
| " 12 | 1 | 6 | 1 | 8 | 4 | 34 | 48 |
| " 13 | 1 | 7 | 4 | 12 | 4 | 38 | 57 |
| " 14 | 1 | 8 | 3 | 15 | 3 | 41 | 64 |
| " 15 | 3 | 11 | 4 | 19 | 4 | 45 | 75 |
| " 16 | 3 | 14 | 3 | 22 | 4 | 49 | 85 |
| " 17 | 3 | 17 | 2 | 24 | 5 | 54 | 95 |
| " 18 | 3 | 20 | 4 | 28 | 5 | 59 | 107 |
| " 19 | 3 | 23 | 3 | 31 | 3 | 62 | 116 |
| " 20 | 3 | 26 | 3 | 34 | 3 | 65 | 125 |
| " 21 | 3 | 29 | 4 | 38 | 4 | 69 | 136 |

with the Mongolians earliest and best layers and the black-necks latest and poorest.

The controls were not subject to as much disturbance as were the experimentally lighted birds of any of the varieties nor to as close confinement. By night-lighting, the black-necks were induced to lay from February 24 onward instead of April 7, 43 days earlier than the controls; the ring-necks from February 21 instead of April 6, 46 days earlier; and the Mongolians from February 28 instead of April 2, 39 days the first 15 days or 0.483 per hen per day; ring-necks, 38/4 or 9.5 eggs per bird in 16 days or 0.5938 per hen per day; Mongolians, 69/4 or 17.25 eggs per hen for 20 days or 0.8625 eggs per hen per day. Corrected for the first 15 days of laying these are:

| | *Controls* | | *Experimentals* | |
|---|---|---|---|---|
| Black-necks | 4 hens | 0.483 | 3 hens | 0.377 |
| Ring-necks | 4 hens | 0.566 | 2 hens | 0.322 |
| Mongolians | 4 hens | 0.816 | 5 hens | 0.573 |

Two hundred and fifteen (215) eggs were obtained from the experimental

hens before their return to normal days and conditions more like those of the wild. After return to the larger pens and cover, the usual cessation of laying after a few days occurred, followed by laying at a slower rate by all three varieties of pheasants as in the previous experiment with ring-necks (Bissonnette and Csech, 1938a). After laying some scattered eggs, the Mongolians built two nests, laid clutches of 12 and 13 eggs, and began incubation; black-necks laid one clutch of 12 eggs and set on them; the ring-necks laid only two eggs loose in the pen.

The clutches from these nests were removed on May 25 and reset under hens. The mongolian clutch of 13 gave 11 chicks, one broken egg and one more fertile; the clutch of 12 gave 8 chicks and one other fertile egg. The black-neck clutch of 12 yielded 10 chicks and one other fertile egg. Hatchability of eggs from controls was correspondingly high this season, possibly due to a very effective feeding regime.

## DISCUSSION

It was urged against our previous experiments that, while the hens activated by extra lighting laid numerous eggs before the normal season, they ceased to be useful thereafter as they would not lay fertile eggs in nests after return to normal wild conditions nor incubate them. The present results show that these objections do not apply at least to Mongolians and black-necks. Some individuals of these varieties, though probably not all, will lay and incubate eggs in nests even after previous forced reproduction. Results with the ring-necks can hardly be considered conclusive.

## SUMMARY AND CONCLUSIONS

1. Black-neck, ring-neck, and Mongolian pheasants were subjected to increased night-lighting from January 6 to April 3, in small pens without cover, and then released into larger pens with abundant cover but only normal periods of daylight, similar to those of controls of each variety.

2. Eggs per hen per day laid before April 3 averaged 0.377 (3 hens), 0.322 (2 hens), and 0.573 (5 hens), respectively, for the experimentals for the first 15 days of laying and, for four control hens of each variety, 0.483, 0.566, and 0.816, respectively. Aside from the two ring-necks no change in the order of productivity was induced. In view of the fact that one cock to 7–9 hens per pen has proved to be the optimum number for both production and fertility among the pheasants at this sanctuary (unpublished data), the above figure for ring-necks probably is relatively too small.

3. Lighted birds began to lay on February 24, 21, and 28, respectively; controls on April 7, 6, and 2, respectively; the changes in order of commencing are probably not significant.

4. Ten experimental hens produced 215 eggs before April 3, the fertility and hatchability of which were high.

5. After return to normal day-length, and larger pens and cover, on April 3, the two ring-neck hens laid only two eggs loose in the pen and built no nest. Black-necks laid some eggs loose in the pen but also built a nest and began incubation of 12 eggs in it. The Mongolians did likewise, but built two nests and set on clutches of 12 and 13 eggs.

6. Reset under hens, these clutches gave 91 per cent fertility and 83 per

cent hatch for black-necks, and 87 per cent fertility and 79 per cent hatch for Mongolians. Controls also gave high fertility and hatchability.

7. Under the conditions of this experiment, black-necks and Mongolians can be used to secure numerous fertile eggs by night-lighting for artificial incubation and can then be planted in the wild with strong likelihood of their producing useful numbers of clutches of fertile hatchable eggs and incubating them during the immediately following normal breeding season. Ring-necks seem to be less adaptable for such double use.

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# STUDIES OF THE GRIT REQUIREMENTS OF CERTAIN UPLAND GAME BIRDS[1]

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Grit has been recognized as essential to most birds as an aid to the gizzard in grinding, and has been suggested as a possible source of necessary minerals. Leopold (1931) says that the peculiar correlation of pheasant success with glaciated conditions may be due to the quality or quantity of lime or grit found in these areas. Despite the recognized importance of grit, there has been little research upon its utility to game birds.

The purpose of the present study was to ascertain more fully the importance of grit to game birds and to determine qualitative standards for appraising this item of the diet. Two species were used, the ring-necked pheasant, *Phasianus colchicus torquatus*, and the bobwhite quail, *Colinus virginianus virginianus*. The experiments were conducted in floored pens, thus permitting complete control over the available grit.

## Grit Starvation

The effects of a complete absence of grit from the diet of birds best illustrate the importance of this material. Some experimental work has been done along this line. The report of the British Committee of Inquiry on Grouse Disease (Anon., 1912, p. 110), hereinafter referred to as the Grouse Report, records an experiment in which two captive grouse were fed a gritless ration. An examination of droppings revealed, after the second day, a marked reduction in the number of grits passed, thus indicating ability of the birds to conserve their supply. One of them died on the twenty-first day and its gizzard was found to contain " . . . still no less than half of the original contents, all of which had been in the gizzard for at least three weeks." Errington (1931) found that six bobwhite quail starved for grit for an average of forty-two days, lost in weight an average of 18 grams, whereas an equal number on a dirt floor lost only about 7 grams each. Losses of weight by the first group were found to be greatest after six weeks. In this experiment, as in that recorded in the Grouse Report, the birds were found to conserve grit.

In the present investigation an experiment was planned to study further the effects of grit starvation. Eleven quail were provided with gravel grit from December 21 until December 29. On that date their supply of grit was removed, and for fifty-one days, until February 18, they were completely deprived of replacement grit. Each day the droppings were carefully collected and the grits recovered and counted.

After the fifth day of forced abstinence there was a marked reduction in the number of grits excreted. On only two days, after this date, were more

[1] Paper No. 1630 of the Scientific Journal of the Minnesota Agricultural experiment Station. This represents a cooperative study between the Minnesota Department of Conservation and the University of Minnesota. Assistance in the preparation of these materials was furnished by personnel of Works Progress Administration, Official Project No. 165-71-6999-3-400.

than two grits passed per bird, whereas previously as many as eleven per bird had been excreted daily. This supports the contention that conservation of grit takes place when fresh supplies are unavailable.

Three birds died during the gritless period, one on January 28, after 30 days without grit; another on February 4, after 37 days; and a third on February 14, after 47 days. Post mortem examination of their gizzards showed them to contain 99, 51, and 142 grits, respectively.

The three birds weighed 116, 133, and 117 grams—decidedly underweight as indicated by the average of the remaining birds, taken on March 4, which was 154.9 grams. Two of the dead quail were autopsied in Dr. R. G. Green's bacteriological laboratories, but nothing of a pathogenic nature was found to which their deaths could be attributed. This would suggest something associated with the lack of grit as the lethal factor.

Errington says that his birds lost weight rapidly after the sixth week. Possibly the sudden loss of weight by Errington's birds and the deaths resulting during the experiment here reported were due to a deficiency of mineral resulting from lack of a fresh supply of grit.

On February 18 the birds were once more supplied with grit. On the second day the number of grits excreted rose abruptly, and continued at a high level for approximately two weeks, varying from 10 to 17 per bird per day. This was accompanied by a correspondingly increased consumption of grit. From then on, however, the number of grits passed, gradually declined, decreasing to 5 per day on the last day. Had the need been only for making good the loss in numbers of grits during the starvation period, certainly there would have been no reason for this great increase in grit excretion; it strongly suggests need for the passage of fresh grit through the digestive tract to permit the extraction of mineral matter.

The eight survivors of the grit deprivation period were weighed individually for four consecutive weeks following the restoration of grit to determine whether a gain in weight would result; the average individual gain was not significant, being only 1.3 grams. These birds manifestly had not lost weight at the same rate as those which died; hence it seems possible that it is only those birds whose reserves of mineral are at a very low point which undergo any great losses of weight resulting from grit starvation.

The evidence seems undeniable that certain gallinaceous birds are able to conserve their supply during periods when grit is unavailable. The method of retention is, however, still a matter of conjecture. The Grouse Report (p. 111) states that when additional grit becomes unavailable " . . . it may be that less food is eaten as well, and thus loss of grit is automatically reduced." In the experiment here described, the average daily consumption of food was measured during both the gritless and the grit-provided periods. During the time when grit was given, the average daily intake per bird was 11.5 grams; during the grit-starvation period, consumption was actually greater, averaging 13.1 grams per bird. In this case, at least, some other explanation must be looked for to explain the method of grit conservation.

Droppings were collected from a group of six captive pheasants, during a period when they were known to be consuming an abnormally large amount of grit, and analyzed individually for the grit contents. In one group of 54 droppings, 266 grits were recovered, all of which were found in only 14 of the droppings. One dropping contained 57 grits, another 49, and a third 37. Another group of 154 droppings contained 782 grits, which were found in only 50 out of the total number of droppings. One dropping contained 58 grits, another 54, and a third 44.

When it is considered that very seldom is a bird of a grit-taking species found which has no grit in its gizzard, even though no other contents are present, it is hard to explain why approximately two-thirds of the droppings of captive game birds should contain no grit at all. Were its passage an unregulated process, every dropping would be expected to contain some grit. Control in some way by the gizzard seems to be the cause.

The Grouse Report (p. 166) says that the food is separated from the grit in the gizzard by the action of the sphincter muscle at the exit of that organ. Possibly it is this same action which regulates the passage of grit from the gizzard, and thus in some way controls its loss during grit starvation periods.

### GRIT AS A SOURCE OF MINERALS

No research as come to the writer's attention regarding the mineral-grit relationship for game birds. The Grouse Report (p. 112) says: "The strongest evidence that quartz is the most suitable form of grit is its universal presence in all the vegetable feeding birds that can obtain it. Red Grouse, Ptarmigan, Black-game, and Capercailzie, as well as Pheasants and Partridges . . . , and Scandinavian Willow Grouse, all collect quartz, and nothing but quartz, if it is by any means to be obtained." If this is true, the possibility of these birds obtaining minerals from their grit is slight, for quartz is essentially insoluble. Leopold (1936, p. 267) says: "It is probable that grit performs not only a mechanical function, but that the soluble parts of it may also be absorbed to fill some small, but insistent need for mineral substances." The Imperial Chemical Industries Game Researches (1937), hereinafter referred to as I.C.I. Game Researches, suggest quartz as the ideal type of grit, but add that oyster shell is a valuable additon to the grit just before and during the laying period " . . . as it provides lime and other minerals which assist in egg formation."

In experiments to learn whether grit serves both as a grinding agent and as a source of minerals, it was therefore decided to use quartz grit. This material serves excellently as a grinding agent, yet provides none of the essential minerals, being composed of silicon dioxide, which is insoluble in most reagents. Thus by its use one of the functions of grit could be eliminated without affecting the other.

Two groups of five ring-necked pheasants, three of which were growing individuals, were placed in floored pens. They were fed *ad libitum* a mixed grain ration and were given green material throughout the experiment. No animal matter was included. On August 22 the five birds in one pen were provided with quartz grit. Consumption of the grit was determined by daily weighings, the

results of which are illustrated in Figure 1.

After two weeks on this ration, the birds, especially the immature individuals, were obviously suffering from

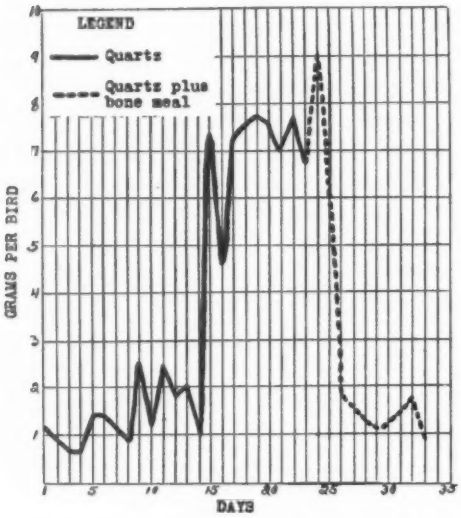


Fig. 1. Consumption of quartz grit and the effect of a bone meal supplement, using three immature and two mature birds.

For the entire length of the experiment the birds received quartz as the only source of grit. On the twenty-third day bone meal was added to the ration.

some sort of deficiency, for from that time on they were frequently observed picking at their droppings. Grit consumption began to rise almost from the start and it was suspected that this might be due to the failure of the quartz grit to supply needed minerals. Accordingly on September 13, bone meal (tricalcium phosphate) was mixed freely in the ration. Consumption of quartz, as a result, dropped from 33.0 grams on September 13 to 1.3 grams on September 18. Apparently the bone meal supplied the required factor lacking in the quartz grit.

From August 22 to September 9, the five birds in the other pen were provided with a mixed type of grit obtained from glacial gravel. It was thought that this gravel would be similar to the type of grit available to the birds on the surface of the ground, especially in certain glaciated areas. Consumption of grit was again determined by daily weighings, the results of which are shown in Figure 2.

Grit consumption during this period remained relatively constant, never rising above two grams nor falling below one gram after the fourth day. Evidently this type of grit was satisfactorily meeting the needs of the birds. On September 9 the type of grit was changed to quartz; shortly thereafter came a rise in consumption. On October 4, the birds were again supplied with the gravel grit, and consumption dropped from 30.7 grams on that day to 1.9 grams on October 8.

On October 4, after twenty-five days on the quartz grit, two of the birds were obviously abnormal. One, a mature hen, had completely lost the use of her legs and had to fly in order to move about. The other, an immature male, had lost the efficient use of one leg and spent most of the time reclining in one corner of the pen. The development of this bird's plumage was also noticeably behind that of the other young birds. It was due to the condition of these two birds that the type of grit was changed from quartz to gravel on October 4. The following day the hen had regained the use of her legs and was able to get about normally. Recovery in the case of the young male was not so rapid, but by October 22, after eighteen days on the gravel grit, except for a noticeable

limp in one leg, this bird had completely recovered. A more normal appearance of its plumage also was evident.

Apparently, therefore, the gravel grit was supplying a mineral or minerals lacking in the quartz grit, and furthermore, whatever the minerals were, they were contained in both the gravel grit and the bone meal. Since bone meal is composed chiefly of two mineral elements, calcium and phosphorus, it became necessary to determine which of the two was of value, if both were not equally important.

Using a third group of birds, calcium alone, as calcium carbonate, was supplied, and, since the results were the same as in the bone meal experiment, calcium was proved to be the important element required in grit. This finding is supported by the fact that phosphorus is unlikely to be found in grit in more than trace-proportions. Furthermore, the organic portion of the natural diet probably would furnish a sufficiency of this element. Since grains are known to be deficient in calcium, it would suggest that birds whose diets are almost en-

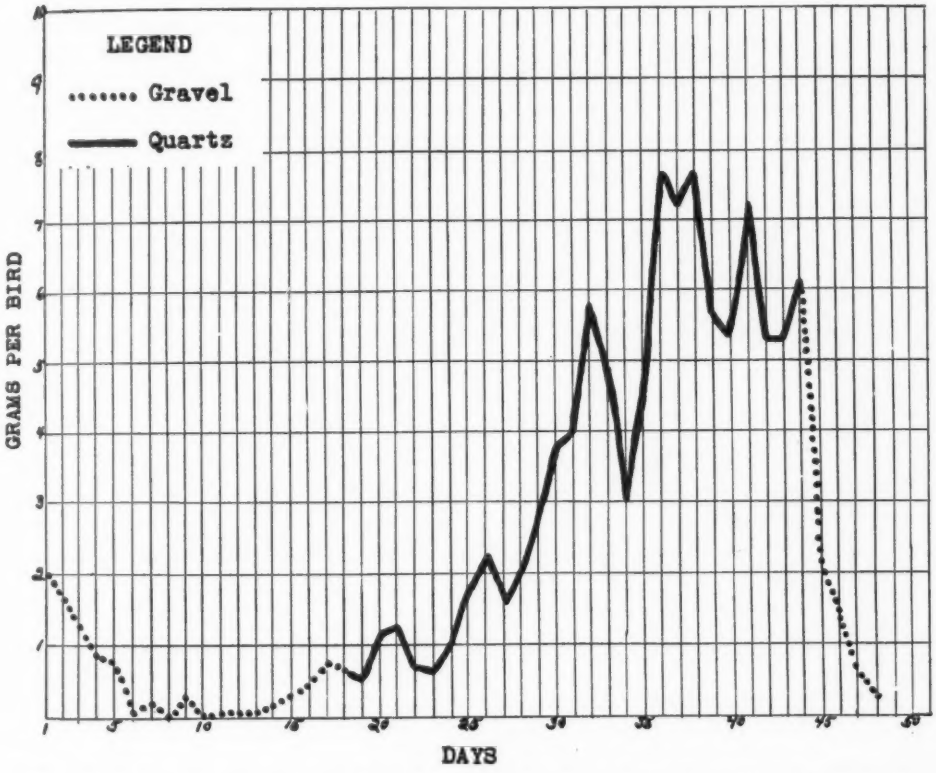


Fig. 2. Grit consumption as affected by gravel grit and quartz grit, using three immature and two mature birds.

Gravel was provided from the first to the eighteenth day, quartz from the eighteenth to the forty-fourth day, and gravel again from the forty-fourth to the forty-eighth day.

tirely grains (or made up largely of any other material deficient in calcium) are dependent upon grit for part of their indispensable supply of calcium.

Inasmuch as three of the pheasants in each part of the experiment were growing birds whose mineral requirements would consequently be great, the test was repeated with mature individuals. Six birds were used for the major portion of this experiment, but on February 17, one had to be removed because of excessive fighting; otherwise the same conditions prevailed as before.

From December 23 to January 3, gravel grit was provided and was replaced on the latter date by quartz, which was then supplied until the end of the experiment. On February 11, a supplement of powdered calcium carbonate was provided in a container separate from that used for the grit. The consumption of grit was determined at frequent intervals and the daily averages for these intervals computed. The results are shown in Figure 3.

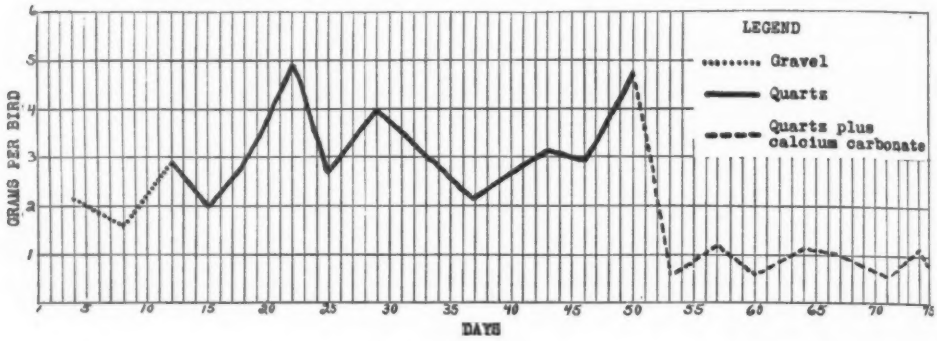


Fig. 3. Consumption of quartz grit and the effect of a calcium carbonate supplement, using six mature birds.

For the first twelve days gravel grit was provided. On the twelfth day quartz grit was substituted for the gravel grit and continued to be supplied for the remainder of the experiment. From the fiftieth day on, calcium carbonate was added.

While grit consumption by these adult birds did increase somewhat upon the substitution of quartz, it not only failed to rise as high as in the experiment involving immature birds, but also did not maintain its height once a peak had been reached. The explanation for this is doubtless the greater reserve of calcium in the adults in addition to their less urgent need for it. The addition of the calcium carbonate supplement had the same effect as the bone meal and gravel supplied in the previous experiments.

These experiments indicate that consumption of grit is conditioned primarily by the need for calcium rather than for a grinding agent. In support of this hypothesis are the results of an experiment in which eight bobwhite quail were found to consume just as much grit while being fed grain ground to flour-like texture as when they were receiving entire grains.

## OTHER STUDIES

Only two references could be found

regarding the size of grit used by game birds. The I.C.I. Game Researches presents figures for the average size of grit utilized by various game birds, that for pheasants being 3/16 inches. Dalke (1938), examining over 600 grits selected at random from the gizzards of pheasants, found the average diameter to be 6.0 mm. and the largest to be 18.3 mm.

In connection with the present study an experiment was conducted to determine the reaction of the birds to grit of unusual fineness. From October 19 to November 8, seven adult ring-necked pheasants were fed grit that had been sifted through a screen of 1.6 mm. mesh. For six days previous to this period and for 18 days following it, the birds were fed grit of mixed sizes. Consumption during the earlier and later periods, when the birds were receiving variable-sized grit, averaged 3.9 grams per day for the group, but was nearly three times as great when only the fine material was provided, averaging 14.5 grams. That this increase is associated with the change in grit size is indicated by the immediate rise in consumption following the provision of the fine grit, from 4.6 grams on October 18 to 15.4 grams on October 19.

It was also found that the birds consumed and successfully eliminated grits more than 6 mm. in size. Using the greatest diameter of the smallest cross-section as a standard, as it is this dimension which limits the passability of these irregularly shaped objects, grits of 7.5 mm., 7.0 mm., 6.9 mm., and 6.5 mm. were found among those passed.

In another experiment an attempt was made to determine whether the birds were able to select between grit types. The statement in the Grouse Report that quartz is preferred would seem to indicate such ability. A group of five ring-necked pheasants was offered a choice of three kinds of grit: pure quartz, limestone, and gravel, each in a separate container. The position of the containers was shifted, and the consumption of the three types was determined daily. During the seven-day period of the experiment the birds consumed 31.6 grams of the gravel, 11.2 grams of limestone, and 8.6 grams of quartz. Not only did they take almost three times more gravel than either of the other two grits, but the daily consumption of this material also was highest in every case, indicating decided selective ability. Since there was no significant difference between the weights of the three kinds of grit used, the figures represent real differences in volume consumption. Why the birds should prefer gravel, however, was yet to be explained.

In some of the food habits studies conducted with birds collected in the wild, consideration has been given to the grit contents of the birds examined.

McAtee (1905), writing about horned larks, says the birds " . . . use a very large amount of gravel to assist in grinding their food, and, strange as it may seem, nestlings have more of it in their stomachs than adults. Now, it has been supposed, since granivorous birds usually eat much gravel, and since exclusively insectivorous birds such as cuckoos, take almost none, that its function is the grinding of seeds to aid in their digestion. But why the thin-walled stomachs of fledglings should contain so much gravel is a question for which no satisfactory answer has been found."

Severin (1933, p. 102), considering the grit found in the crops and gizzards of 285 pheasants collected in South Dakota, found that only 33 of the crops but all of the gizzards contained stones. These were principally quartz pebbles, although some calcareous material also was present. The largest number of grits contained in any single gizzard was 1,886, of 4 cc. in volume, while the smallest number was 10 (0.17 cc.). The largest volume of stones found in any single gizzard was 9 cc. (numbering 73) and the smallest volume 0.17 cc. (of only 10 small grits). For the entire year, the average gizzard grit content was 266.9 stones, of 3 cc. in volume; the monthly averages, however, were so variable that no condition or combination of conditions could be thought of to explain them.

Dalke (1938) also found the amount of gravel contained in pheasant gizzards to vary greatly during the year. A larger amount of grit was present during the breeding months, especially in females, as much as 10 grams of gravel being found in the gizzards of laying hens. This increased consumption of grit, the author concludes, " . . . may be closely correlated with egg production." Young birds were found to utilize grit soon after starting to eat, and the indications are that grit is taken regularly by the birds from one day to three weeks of age, after which consumption becomes less regular.

## THE DISTRIBUTION OF GAME BIRDS CORRELATED WITH THEIR GRIT REQUIREMENTS

Experimental evidence, based on studies with the ring-necked pheasant, indicates that game birds whose diets are composed chiefly of calcium-deficient materials, such as grains, are dependent upon grit for part of their supply of essential calcium. The possibility therefore exists that the distribution and welfare of such birds in any area could be influenced by the presence or absence of calcium-containing grit. Food habits studies have shown the ring-necked pheasant to be perhaps our most completely granivorous game bird, and, should such an influence exist, it is probable that it would act most strongly on this species.

In this regard, the general failure of the pheasant in the South is especially interesting. Leopold (1936, p. 268), says: "The grosser aspects of climate seem to be ruled out as a primary cause by reason of the known success of pheasants on game farms in the zone of failure, and by reason of the fact that the failure of plantings is gradual, the planted stock at first breeding vigorously, but later 'straggling' to an ultimate decline. Replenishments by new plantings, however, seems to renew the vigor of the stock, so that we have 'artificial establishments' even as far south as Georgia. The grosser aspects of food, cover, predators, poaching and disease seem to be ruled out by reason of the consistent behavior of [the] . . . species within its zone of success and failure respectively. These highly variable factors would, if controlling, produce a 'shotgun' pattern of successes, whereas the actual pattern, . . . , is solid."

In the north central region successful plantings of the pheasant, as well as of the Hungarian partridge, were found by Leopold (1931, p. 125) to be confined mostly to soils of recent glacial

origin. He says, therefore, that "It is possible that the fresh glacial deposits contain lime or grit of a quantity or quality necessary to the welfare of these birds" or "It is also possible that the glacial soils support some plant or insect which contains some vitamin or mineral substance necessary to the welfare of these species" (p. 126).

Since calcium-containing grit appears to be an important factor in the welfare of the pheasant, and since pheasants seem to be largely confined to recently glaciated areas in some regions, it becomes of interest to attempt to determine whether soils of recent glaciation are especially rich in calcium-containing gravel.

It is a fact that certain glaciated areas do have an excellent distribution of limestone fragments and other stones coated with lime. For example, the young gray drift, covering most of western and southern Minnesota, eastern North and South Dakota, and part of northern Iowa (an area, in general, noted for its heavy pheasant population), is especially rich in calcium-containing material. This drift owes its high calcium content to the fact that it was deposited by ice coming from Manitoba, which carried with it an abundance of limy material (Stauffer and Thiel, 1931, p. 93). Thus it can be seen that areas covered by glaciers bearing such limy material might be expected to have a better distribution of calcium-containing grit than areas covered by glaciers not so characterized or areas entirely undisturbed. The solid pattern of success for the pheasant in certain glaciated areas could possibly be due to this reason.

If the presence of calcium is the critical factor, then areas where this element occurs naturally in sufficient quantities should be as suitable for pheasants as areas possessing calcium of glacial origin. Thus the known success of pheasants in certain unglaciated areas could be accounted for. This point is illustrated by the statement of Gerstell (1937, p. 508), to the effect that, "In any discussion of Pennsylvania pheasant densities, the fact cannot be overlooked that almost without exception, the heaviest populations are found in limestone sections, where the points of greatest density seem to surround out-croppings of Trenton limestone such as are found in the cement manufacturing belt of Lehigh and Northampton Counties."

The question of why native species should range indifferently is difficult to answer. If it is calcium that is at the root of the problem, then two possibilities exist; either (1) their requirements for this element are not as great, or (2) something in their diet, other than grit, supplies them with more of this element.

Before any definite conclusions can be drawn, a detailed study of game bird distribution correlated with the presence or absence of calcium-containing gravel would have to be made. The possibility exists, however, that this relationship with calcium may be one of the less apparent but important factors affecting some of our game bird populations.

## SUMMARY AND CONCLUSIONS

1. Under experimental conditions the reaction of quail to grit starvation varies. Some lose weight and die, while others are able to maintain themselves.

The reserve of mineral in the survivors probably is the determining factor.

2. Evidence from these and other experiments indicates that gallinaceous birds are able to conserve their supply of grit during periods when replacement is out of the question.

3. Game birds whose diets are composed almost entirely of grains, or other materials deficient in calcium, are probably dependent upon grit for part of the indispensable supply of this element.

4. Glaciated gravel such as is found in the area in which these experiments were conducted is entirely satisfactory as a source of calcium.

5. Adult birds seem better able to maintain themselves on grit deficient in calcium than young birds. This is undoubtedly due to their greater reserve of, and smaller demand for, this element.

6. Consumption of grit appears to be conditioned by the need, primarily for calcium, and secondarily for grinding material. Birds with an insufficient calcium supply, therefore, feed more heavily upon grit than birds entirely satisfied in that regard.

7. Consumption of fine grit (less than 1.6 mm.) was found to be approximately three times greater than that of larger grit.

8. Experimental birds were found able to select between three types of grit, preferring glacial gravel.

9. The possibility exists that the presence or absence of calcium-containing grit has an effect on the welfare and distribution of certain game bird species.

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# HAWKS VS. QUAIL ON QUAIL PRESERVES

*H. L. Beadel*[1]

Most people that I know, including sportsmen, subscribe to the common belief that the only good hawk is a dead hawk, and think it odd when told that I never shoot a hawk unless I catch it in an accomplished "crime," and then —and not always even then—only if it is a Cooper's or a Sharp-shinned Hawk, known here as "blue darters." And I have been asked by several how I came to adopt that policy.

As I have shot various kinds of game all my life and own some quail land, they cannot class me as a "sickly sentimentalist," yet no other explanation seems to occur to them.

Though I confess to being a "sentimentalist" to the extent that the presence of all forms of wild life besides whatever game I may be hunting adds vastly to my interest and pleasure in the field, my reason for sparing hawks is primarily a *practical* one, because observation has taught me that far from being detrimental, they are valuable to a quail preserve.

On the one hand, I sympathize with the farmer who kills a hawk that persistently preys on chickens or ducks that he cannot well keep confined at all times. On the other hand I do not sympathize with the professional game breeder or chicken raiser who depends on the gun or trap to protect his stock when he could attain his purpose more effectively—in fact completely—by the use of wire mesh, as has become the general practice.

As a boy, like others, I considered the killing of a hawk a good deed until I came across a copy of "Hawks and Owls of the United States" by A. K. Fisher, published in 1893 by the U. S. Department of Agriculture. The book is out of print and seems to be little known to the public, or even to sportsmen, so I will say here that it presents a record of the stomach contents of several thousands of hawks and owls of all our American species.

It shows so clearly that only a few species subsist principally on birds and that the diet of the great majority consists mainly of other things, among them rodents and snakes some of which destroy young birds and eggs, that it should convince any one of open mind that hawks in general do far more good than harm. At any rate it impressed me to the extent that I gave them the benefit of the doubt from then on, and subsequent observations in the field have further convinced me that they deserve it more often than not. I wish that the book[2] could be revised and reprinted for general distribution to help develop a

[1] Mr. Beadel was a subscriber to the fund that maintained the Cooperative Quail Investigation 1924–1929, and is Secretary of the succeeding organization, the Cooperative Quail Study Association 1931– . He has been at all times an ardent supporter of the Director Herbert L. Stoddard, our fellow member in the Wildlife Society.—Editor.

[2] U. S. Department of Agriculture Circular 370, Food Habits of Common Hawks, 1935, epitomizes information on its subject. It may be had from the Superintendent of Documents, Washington, D. C., for 5 cents a copy (stamps not accepted).—Editor.

practical common sense attitude among our vast army of gunners and sportsmen, including the owners of quail preserves, in the interests of their own sport.

Before stating the results of my personal observations a word or two as to my quail shooting "background" may not be amiss. As a boy I shot quail for several seasons in North Carolina and northwestern Florida. Then followed some years when opportunities were lacking. I resumed shooting in northwestern Florida about twenty-five years ago and have shot nearly every season since, the last eighteen years on my own land near Tallahassee. I have also studied birds in the field during part of the closed seasons.

My preserve is small as quail preserves go—about 2000 acres of good quail land after deducting such areas (dense hammocks, etc.) as do not furnish much sport. It has been in my family over forty years, so I am familiar with its history and can state positively that no trapping or systematic shooting of hawks has ever been practiced, and except for a few hawks looking for easy meat around chicken yards, practically none have been killed on the property.

As up to the time that I came into possession there had been an abundance of quail in spite of the absence of hawk control, I resolved to proceed on the theory that our native quail if provided with adequate food and cover and not overshot, will provide a reasonable amount of sport year after year without hawk control or the importation of birds from outside.

Results appear to have justified this policy, as except in years due to bad breeding seasons, when the quail population was below normal over much of this region, my stock has been sufficient to allow of an average yearly bag of between 300 and 400 without undue reduction of the carry-over, as shown by the size of the coveys at the end of the season, few numbering less than five or six and the majority eight or more. In proportion to acreage this compares favorably with southeastern preserves of similar topography, and food and cover conditions regardless of what predatory control measures may have been practiced on them. I allow each tenant one (male) dog only; and the keeping of cats is discouraged—any cat met away from a house being subject to elimination on sight. Though no systematized control of the four-footed predators has been undertaken, there has been a certain amount of incidental control through coon and possum hunting at night by negro tenants, in the course of which some skunks are killed. So I think that we may assume that conditions in respect to four-footed predators, as well as food and cover, as mentioned above, are about the same on my land as elsewhere.

Due to my special interest in learning how much depletion my coveys might be suffering from hawk depredations, I have constantly kept my eyes open for instances of successful attacks, yet have seen very few—perhaps a dozen all told—and some of those were on quail that had been slightly crippled by shot.

I note throughout the season the number of birds in a covey each time it is flushed, and the diminution in numbers has usually been accounted for by the number bagged when the covey was last shot into. So I can state with-

out hesitation that the damage done by hawks to my coveys during the shooting season is negligible.

This inspires the query: Why is it so generally assumed that hawks constitute a *serious* menace to the quail population?

I believe the answer lies in: (1) thoughtless acceptance of tradition; (2) lack of interest in the habits of any birds except the game that is being hunted; (3) snap judgement and erroneous interpretations based on incomplete or faulty observations of such few cases as the average hunter, who shoots only a few days a season, is apt to encounter; and (4) resentment at the hawks' "impudence" in even trying to infringe on what the hunter is prone to regard as his exclusive rights.

It takes long experience, patience, and an open mind to acquire the faculty of accurate observation, and the experienced observer has learned not to build theories, nor to act, on scanty data which the untrained observer might accept as conclusive.

A slow-flying hawk, such as the red-tailed or red-shouldered will often hang about and make an occasional dash at a covey. It is as a rule, too slow to catch a healthy quail—though it might bag a semi-cripple—but its swoop scatters the covey, the quail squeal, and the average man, impressed by the riot, would assume that the hawk had made a capture and think: "What a lot of birds that dashed hawk must destroy. Just let me get a shot at him." If he kills it he feels that he has saved the lives of countless quail, not realizing that the hawk if spared would later have saved at least some quail eggs and chicks by destroying some of the rodents and snakes which eat them. Even the slowest hawks can catch rodents and snakes, but it takes a fast hawk to catch a healthy quail; a cripple is best eliminated anyway. The Cooper's and the sharp-shinned can seize a quail if they can surprise it far enough away from cover, but in cover they often miss. More than once I have seen one of these hawks disappear into a thicket on the tail of a squealing quail, and hearing nothing more, supposed that the quail had been caught, but on approaching the spot, the hawk rose and made off with empty claws. If I had not investigated I would have been left with the impression that hawks get quail at almost every dash.

As an instance of how easily one might be fooled, here is a case that I witnessed last winter: While hidden in a thicket at the edge of a field waiting for a shot at a turkey, a Carolina dove whizzed across the field and dived into the bushes with a Cooper's hawk crashing through the twigs almost upon it. As the dove grazed the ground within 20 feet of me the hawk struck in an explosion of dead leaves and I thought it had the dove. But the next instant I caught sight of the dove dodging through the thicket while the hawk was sitting with wings half open and legs braced, looking dazed. It took about a minute to pull itself together and flop off. If I had not happened to be in a position to see exactly what had happened I would have felt sure that the hawk had made the kill.

In some years during the shooting season we have seen many more hawks than in others; but as the quail population was about the same in each case it appears probable that such concen-

trations of hawks were not due to the attraction of the quail, but to a superabundance of cotton rats or other rodents which have marked cycles of abundance and scarcity and which are important items on the bill of fare of many species of hawks. So instead of regarding the presence of hawks as a menace to my quail I am glad to see them on the job.

A parallel case is furnished by alligators, turtles, and fish. Because alligators eat some fish, it was thought desirable until comparatively recently, to kill them. But we know now that alligators eat turtles, and there are indications that turtles eat roe and young fry, so killing the alligators may allow the turtles to multiply to a point where they menace fish production. Anyhow, when alligators were abundant in Florida lakes and ponds there was a greater abundance of fish than there is now. At present we see few 'gators but many turtles. A movement initiated and supported by fishermen to protect alligators is under way, and I would like to see a similar movement supported by sportsmen, in their own interests, to protect hawks, which—especially the slow, beneficial but most easily killed species—have been greatly reduced in numbers.

I might make an exception of the "blue darters" if the average man had the knowledge to distinguish them from other species. But as that is not the case, I advise leaving all hawks alone rather than risk killing the beneficial ones by mistake.

It is only fair to remark that most of the fields on my property are small, so that the quail are never very far from cover while feeding. On preserves where the fields are large and unbroken by hedgerows or other cover, the fast hawks no doubt kill more quail than they can on mine, though probably not as many as is popularly assumed for, as a rule, quail do not venture far from cover. But it is not hard to provide escape coverts, which is all that is needed to afford practical protection from even the "blue darters," which are the true bird-killing hawks. That done, hawk damage will be negligible while hawk benefits will continue.

To sum up: My experience indicates that an above-average quail population can not only be maintained, but is more easily maintained by leaving hawks unmolested than by killing them.

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# THE FOOD AND FEEDING HABITS OF THE RED-BREASTED MERGANSER IN BRITISH COLUMBIA

*J. A. Munro and W. A. Clemens*

In view of the observed fish-eating habits of the Red-breasted Merganser (*Mergus serrator*), the question has been raised as to the relation of this duck to the fisheries of British Columbia. It has seemed advisable therefore to present at this time some data which the authors have obtained during the past several years.

This study has been carried out as a joint undertaking between the National Parks Bureau of the Department of Mines and Resources and the Pacific Biological Station of the Fisheries Research Board of Canada.

The authors are greatly indebted to officers of the Dominion Department of Fisheries, and the Game Commission of British Columbia for providing many of the specimens.

## Distribution

The Red-breasted Merganser has a circumpolar distribution. In North America the summer range includes the northern part of the continent from Nova Scotia to Alaska, the southern limit of distribution being at higher latitudes in the western part of the range. The wintering grounds comprise the Great Lakes, inland waters to the south and the Atlantic and Pacific coast regions (Fig. 1).

The nesting area of the far western portion of the continent lies, for the most part north of the 60th parallel of latitude. Munro and Clemens (1937) stated that the species had not been recorded as nesting in British Columbia. It is necessary to modify this statement as Swarth (1936) reports a nest with eight eggs on an island in Atlin lake, July 16, 1931 and states that the species is a fairly common summer resident.

On the Pacific coast the Red-breasted Merganser is an abundant winter visitant from southeastern Alaska to lower California. It seems probable that the wintering birds on the British Columbia coast are derived chiefly from breeding populations of Alaska, Yukon, and the Northwest Territories of Canada. No information is available concerning any migration route that may be followed across the northern portion of the Province. In the southern interior of the Province the bird is a scarce migrant and an uncommon winter visitant.

On the British Columbia coast this species occupies a salt water habitat for the most part; only a small proportion of the large winter population frequents fresh water and few travel upstream above tidal influence.

Dates for the arrival of the first fall migrants on the coast are lacking. A flock was seen at Sooke Harbour on September 14, 1934, and several flocks were recorded on Cordova Bay, October 21, 1913. By mid-November the winter population has attained its maximum and following this, little migratory movement takes place until late March or April. The flocks frequenting the lower reaches of the rivers appear to maintain their numbers on the selected streams for most of the

Fig. 1. Definite nesting records (large dots) and principal wintering range (stippling) of the Red-breasted Merganser in North America. Map supplied by P. A. Taverner, National Museum of Canada, Ottawa.

winter, but the sea population shifts from place to place in search of food.

There seems to be some segregation of sexes at this time. The majority of those visiting Departure Bay were adult males and flocks consisting chiefly of females and the dull-coloured yearlings have been observed on the rivers.

On the Tlell River in the spring of 1935 a flock of twenty on May 4 represented the last adults seen. Subsequently, until May 15, one or two yearlings fished in the river, sometimes accompanying a resident group of American Mergansers. Very probably a small population of non-breeding birds remain all summer on the coast.

### FEEDING HABITS

Like the American Merganser this species hunts its prey by sight, swimming quickly along the surface with head submerged below the eyes. When small bands of birds are fishing on salt water they swim close to shore very often in single file and their behaviour after fish have been sighted is in no way different from that of the American Merganser. On the rivers also the feeding actions of the two species are identical.

On salt water much of the feeding activity is centered about the herring which are followed persistently. This is most apparent in the months of February and March in the southern portion of the Province when herring visit inshore waters preparatory to spawning. The mergansers may then appear in flocks of several hundred birds and at such times the feeding behaviour is somewhat modified because of the presence of gulls as described by Munro and Clemens (1931). Usually the arrival of the mergansers follows a commotion amongst the gulls which have sighted the fish. There is a short time of intense activity while the mergansers keep diving and reappearing. Should one emerge with a herring in the bill the bird will rush over the surface with neck outstretched, half flying, half swimming, while a number of gulls follow in close pursuit. Usually the duck will dive again and thus elude the pursuers.

Usually the mergansers do not appear in Departure Bay in numbers until February. On February 16 to 18, 1931, herring were in the Bay and the arrival of the Red-breasted Mergansers, their short feeding period, and the sudden almost simultaneous disappearance of all the flocks was observed at close range numerous times. The ducks first appeared as a line of rapidly moving dots against the sky. They came in flocks of 100 or more, flying at a height of several hundred feet, then slanted down and dispersed in radiating lines amongst a gathering of gulls and other water fowl that was spread over the bay. They surged over the water for several yards with the impetus of their flight. These flocks were composed almost entirely of adult males. Immediately after landing they commenced swimming with heads submerged. During the entire afternoon of February 18, the water in front of the Biological Station buildings was crowded with water fowl of various species which every so often, as herring appeared near the surface, formed dense, struggling packs, some birds on the water, others in the air. After a series of these spectacular exhibitions in which hundreds of ducks and gulls took part, the mergansers suddenly began to rise with

much noisy splashing, reformed their lines and disappeared out to sea.

## FOOD

*Review of literature*

Many of the references to the food of the Red-breasted Merganser are of a general nature, for example, A. C. Bent (1923) refers to the species as a fisheater and mentions crustaceans and mollusks as food items for adults on the sea and small fish, aquatic insects, worms, crustaceans, and frogs as food of the young.

Nelson (1887) reports that the species feeds intensively on sticklebacks which occur abundantly in the brackish ponds and tide creeks of the marshes in Alaska.

A paper by Cottam and Uhler (1936) summarizes the food found in 130 stomachs on a percentage basis as follows: Minnows, killifishes, sticklebacks, 34.23%; carp, suckers, 3.00%; commercial and game fishes (including no trout), 14.38%; unidentified fish remains, 25.08%; crustaceans and miscellaneous, 23.31%. The districts in which these specimens were taken are not recorded.

H. C. White (1937) presents an account of the distribution, nesting and feeding habits on the Margaree River, Cape Breton Island, N. S. In regard to the food he states, "Young birds were found feeding mostly over areas not frequented by young salmon and no remains of salmon were found in them. They were found to be feeding on small fishes, none over two inches in length, including *Catostomus commersonii* and two species of Gasterosteidae. A considerable number of ephemerid nymphs and some other insects were eaten; a half grown individual feeding in a shallow bay on the sea, contained 54 shrimps (*Crago septemspinosus*). Nonbreeding birds were found principally on the estuarian part of the stream. Eleven specimens contained, on a percentage occurrence basis, 68.2% salmon and 31.8% other fishes representing the most recent feeding on fishes in the river. Sea-taken food was represented by a few fragments of fishes in the gizzard indicating that at times they feed upon marine fishes."

John Berry (1935) discussing the food habits of the species in Scotland mentions sprats, young herring, and crabs as the diet from November to April when most of the birds are on the sea. In connection with fresh water habitats one instance of eleven parr and another of small pike being eaten are recorded, while several authorities are quoted in reference to the species feeding on eels and sticklebacks. This author concluded that "Since sticklebacks and eels can be little less serious enemies of young salmon and trout than are pike; it is questionable whether on some waters the Merganser may not do as much good for these fisheries as it does harm."

Munro (1930) records two instances of marine sculpins being eaten and Munro and Clemens (1931) describe the behaviour of the species when capturing herring. So far as known these are the only references to the food taken in British Columbia.

Studies of the material in the digestive tracts were carried out at the same time and in the same manner as in the study of the American Merganser. The methods have been described in detail by Munro and Clemens (1937).

The Red-breasted Merganser material consisted of 112 stomachs containing food. Except in the case of the Cowichan River, from which seventy-seven specimens were available, no one locality is sufficiently represented to be treated separately. For this reason and because there is no great local difference in habitat or feeding conditions the remaining specimens are grouped under three headings: (1) Rivers and lakes, (2) Salt water and river mouths, (3) Okanagan Lake.

### COWICHAN RIVER

Number of specimens: December 18, (2); 20, (8); 24, (3); 26, (1); 28, (10); 30, (10). January 3, (11); 4, (7); 7, (6); 10, (10); 14, (8); 25, (1). Total 77.

*Salmon eggs*—All of the Red-breasted Mergansers taken in December and all but one of the January specimens had eaten Chum or Coho Salmon eggs. This food was represented in the stomachs in quantities ranging from a few fragmentary egg membranes to 235 whole eggs, the average number of whole eggs in the seventy-seven stomachs being 41 and the total number 3,163. Of these 136 were clear and 3,027 in various stages of opacity. Sixty-seven of the latter were eyed. Whole eggs were chiefly in the gullet and proventriculus and in many cases the gizzard contained in addition a mass of comminuted egg cases mixed with sand and gravel. In some instances this ground up material was of greater bulk than the total of whole eggs.

*Salmon flesh*—A fragment of salmon flesh was detected in one specimen.

*Stickleback* (*Gasterosteus aculeatus*)—Bones of several fish were a secondary item in one stomach.

*Sculpin* (*Cottus asper*)—This species was represented in three December and three January specimens.

*Unidentified fishes*—One occurrence is recorded.

*Marine crustaceans*—Three schizopods comprised the chief contents of one specimen; a shrimp, *Pandalus danae*, was found in one and fragment of crab in another.

*Fresh-water crustaceans* (*Gammarus limnaeus*)—These were represented by over twenty specimens in one stomach.

*Insects*—In five specimens insects represented a small percentage of the stomach contents; caddis larvae and cases occurred in three and cranefly larvae in two.

*Summary.* Specimens taken between December 18 and January 14 had eaten salmon eggs almost exclusively, other items being probably incidental to this diet. The only specimen taken later in the month (January 25, 1931) contained sculpins and amphipods only.

### LAKES AND RIVERS

Capilano River, March (1); Owikeno Lake, May (2); Goldstream River, March (3); Chemainus River, January (3); Nanaimo River, February (4); Courtenay River, March (5); Oyster River, May (1). Total 19.

*Salmonoids*—Two specimens taken on the Goldstream River, March 7, 1934, contained in addition to sculpins, at least 6 salmonoid fingerlings in one case and the jaw of a salmonoid fingerling in the other. Thirty-four salmonoid fry comprised the sole item in a specimen taken in May on Owikeno Lake.

*Sculpin* (*Cottus asper*)—This species occurred in fifteen of the nineteen stomachs examined. Whole fish ranged in

size from 30 to 120 mm. and were represented by two to six specimens in each case exclusive of additional bone fragments.

*Sculpin eggs*—Small quantities of small fish eggs believed to be those of sculpin occurred in one specimen from Chemainus River (January 29, 1937) and in one from Goldstream River (March 7, 1934).

*Insects*—One stomach contained a caddis larva in case (Nanaimo River, February 3, 1932) and another contained several (Oyster River, May 7, 1935).

*Miscellaneous*—The specimen from Oyster River contained polychaete jaws indicating prior sea feeding.

*Summary.* While sculpins appear to be the most important food item, it is possible that additional specimens taken in April and May would show a greater consumption of young salmon than is indicated by these data.

### SALT WATER AND ESTUARIES

Point Atkinson, December, (1); Horseshoe Bay, January, (1); Departure Bay, February, (7), March (2); Courtenay, March (1); Comox, October, (1), March (1); Port Hardy, May, (1). Total 15.

*Salmonoids*—One taken at Comox in March contained four Coho Salmon fingerlings; another (Port Hardy, May 9, 1933) contained 7 salmonoids averaging 60 mm. probably spring salmon and 2 other salmonoids measuring 25 mm.

*Herring* (*Clupea pallasii*)—Three herring of the year were the sole item in one specimen from Point Atkinson; one small herring was the chief item in a specimen from the mouth of the Chemainus River, January 29, 1932; adult herring occurred in five specimens from Departure Bay.

*Eulachon* (*Thaleichthys pacificus*)—Two mature fish formed the entire contents of a specimen taken at the foot of Owikeno Lake, May 2, 1931.

*Stickleback* (*Gasterosteus aculeatus*)—Two specimens taken at Departure Bay February 15, 1938, contained plates and spines representing in one case 18, and in another at least 6, sticklebacks; another taken March 3, 1930, contained 2 complete individuals of this species.

*Smooth sculpin* (*Leptocottus armatus*)—A specimen from Departure Bay, February 12, 1934, contained at least 2 individuals of this species.

*Sculpins*—Bones representing at least 5 cottoids were present in one specimen from Departure Bay, February 16, 1934, and remains of several in another taken at Horseshoe Bay, January 15, 1933.

*Blennies* (*Blenniidae*)—Two blennies formed sixty per cent of the food in one specimen from Departure Bay, February 5, 1931.

*Rock fish* (*Sebastodes* sp.)—Fragments of a rock fish occurred in a specimen from Departure Bay, February 12, 1934.

*Unidentified fishes*—Fragments of fishes in two specimens were not identified.

*Crustaceans*—The following were represented in two stomachs: shrimps, *Pandalus* sp. and *Spirontocaris* sp.; crab, *Lophopanopeus bellus*; two specimens contained unidentified crustacean fragments. Fragments of a small decapod formed half the contents of a specimen taken at Horseshoe Bay, January 15, 1933.

*Polychaeta*—Jaws of a polychaete worm occurred in the individual from Courtenay.

*Summary.* The food of the sea-feeding Red-breasted Mergansers consists of a variety of fishes. The data here presented indicate sculpins and herring as the most important items but observation show that at certain times herring are the chief food.

### OKANAGAN LAKE

March (1).

*Sculpin* (*Cottus asper*)—One individual.

*Crustacean*—One crayfish, *Potamobius klamathensis.*

### GENERAL SUMMARY, DISCUSSION AND CONCLUSIONS

The Red-breasted Merganser is an abundant winter visitant to the coast waters of British Columbia where it greatly outnumbers the American Merganser. There is probably also a small coast population of non-breeding birds in summer which is restricted almost entirely to salt water. The species is uncommon at all times in the southern interior.

Thus a study of the economic status of the Red-breasted Merganser in British Columbia concerns only a winter population on the coast region. Because of these limits the problem is less complex than in the case of the American Merganser which involves coast and interior breeding populations in addition to a coast winter population.

The food of the two species while on fresh water is identical. During the period from November to January, Chum and Coho Salmon eggs are taken to the exclusion of almost all other food. Examination of the eggs in the digestive tracts show these to be chiefly opaque eggs. In a discussion on the food of the American Merganser, eggs of this description were regarded as largely a waste product and their consumption by birds and fishes as not affecting salmon production. The same conclusion would apply in this case. There is no evidence that either of the mergansers digs eggs out of the covering gravel.

The data except for the Cowichan River, are far from complete but indicate that in fresh water, sculpins are an important food, these fish being present in ten out of eleven stomachs from specimens which had not been feeding on salmon eggs. On other streams fifteen out of nineteen individuals had eaten sculpins. It is probable that a larger series of specimens would show a greater degree of predation upon salmon and trout.

On the sea the Red-breasted Merganser has a varied diet of marine fishes and crustaceans and in its shoreward feeding and in estuaries sometimes captures salmonoids but to what extent is not known. Probably the most important food taken in the sea is the herring and the presence of these fish in numbers will attract all the small groups of Red-breasted Mergansers that have been feeding inshore until flocks of large size have been assembled.

It is evident from the information presented that the herring is the economically valuable species of fish which is eaten by the Red-breasted Merganser. In view of the very large number of herring and the limitation of the predation for the most part to the spawning period it is inconceivable that the Red-

breasted Merganser can bring about a measurable reduction in the total population of this fish.

There is some evidence that numbers of young salmon are captured in the lower reaches of streams at the time of seaward migration. Further information is necessary concerning the numbers of Red-breasted Mergansers inhabiting the lower reaches of streams and of estuaries and the food taken in such localities before sound conclusions may be drawn as to the relation of the duck to salmon production.

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# A FUR STUDY TECHNIQUE

*F. N. Hamerstrom, Jr. and James Blake*

Techniques for appraising fur management problems are still incomplete. Census methods (1, 2) are generally limited to small areas; large scale surveys (3, 4) draw heavily upon fur buyers' reports and kill records, not everywhere to be had. Fur populations on areas too large to census and lacking figures on the kill are particularly difficult to tally. In any case, fur management must be based on more than census data alone. One must know where, when, and what, as well as how much, to do.

One approach to the problem has been tried out on the Central Wisconsin Game Project, Necedah.[1] The area, a hundred thousand acres of sand and marsh in Wisconsin's Central Plain, was drained for agriculture about twenty-five years ago. Poor soils, high taxes, and too frequent frosts in the drained marsh basins led to the gradual abandonment of most of the farms, and the Federal Government has bought the land. The terrain consists of jack pine-scrub oak woods, old fields, seasonally wet marshes, and aspen and willow flats on burned peat. Where drainage is particularly poor, scattered tamarack-black spruce swamps and leatherleaf-labrador tea bogs have persisted, but they are too few to be important to the fur population. The old ditches are still there, a conspicuous part of the landscape.

Fur management is one of the aims of the Project. There are no kill records available. To get the facts needed in making a management plan, we carried on a furbearer study from May 1936 to August 1937. Because of the size of the Project, we used a system of repeated surveys. At that time the major furbearers—muskrat, beaver, otter, raccoon, mink—were practically confined to the drainage ditches; we designed the survey for stream- and ditch-dwelling animals, but took notes also on whatever skunk, badger, fox, and coyote sign was found along the way. Four men, working in units of two men each, systematically walked the ditches and streams. One man of each pair took the field data, consisting of maps and notes, which were entered in stenographers' notebooks as follows:

(1) On the upper page of the opened notebook a sketch was made of the section (or group of sections) to be covered. The sketch, copied from the Project base map before going into the field, showed section lines, water areas, and such landmarks as roads, bridges, and dams. Each sketch was dated and identified by town, range, and section. The scale, from one to two inches per mile, was indicated by the spacing of the section lines.

(2) Fur sign—tracks, trails, droppings, feed beds, cuttings, dens, etc.—found was added to the sketch by using the symbols partially reproduced in Figure 1. The length of each symbol indicated the estimated distance along which the sign was observed. It was found best to have the mapper take

[1] Project LD-WI-5, Farm Security Administration, Region II; W. T. Cox, Regional Forester-Biologist.

rough notes in the back of the field book or on a separate piece of paper as he worked along the ditch, and to draw in the symbol only when he reached a definite landmark. Except for all dens and all beaver sign, old sign was not mapped. For these exceptions, however, fresh and old sign alike was mapped and distinguished by notations. Thus beaver dams which had been washed out or abandoned, or new ones being built, were so marked.

Fig. 1. Survey symbols with diagram of a one-mile sample of ditch to show their use.

The relative quantity of sign found was described in the field notes as heavy, medium, or light, but generally was not indicated on the sketches. By slight variations of the symbols (Fig. 2) these different classes of abundance

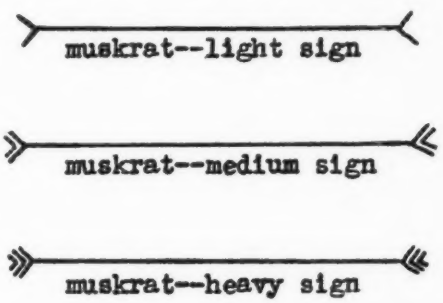


Fig. 2. Symbols modified to show relative abundance of sign.

could easily be mapped directly, thus greatly reducing the bulk of the notes.

(3) Notes on abundance of sign, numbers seen, mortality, easily recognizable foods, water levels, and any observations of particular interest were entered on the page below the sketch. For each unit these notes were arranged by species, so that all notes on any species were together. Conditions which might affect the interpretation of the data, such as a sudden rise in water level which had obscured sign, also were noted.

Collections of food habits material were brought in for identification. As each township was finished, a copy of the record of the fur sign in the sketches was made on four inch-mile township base maps. The same legend was used but each symbol was given a distinctive color to simplify the use of the maps. The date of completion of the survey also was shown on each map.

On succeeding surveys, fur sign, water and feed conditions, etc., were entered in the field books as seen at

the time; then, as each township was finished, a summary was prepared to point out where changes had occurred since the last survey.

Five surveys were run, one each in spring, summer, and autumn, 1936, and spring and summer, 1937. On the last survey the Project's 200 miles of ditch and stream were covered by four men in seventeen days.

A summary of the data obtained for the five major species of furbearers is given as an example of the results of the method.

### MUSKRAT

Repeated seasonal surveys showed first that muskrats were always absent from certain ditches; second, that the animals in the remaining waters did not stay in place but were constantly shifting about, and third, that winter losses were extremely severe.

Well-shaded ditches, and those which were deep and swift through most of the year, were lacking in food and harbored few muskrats. Fluctuating water levels in the best muskrat ditches further lowered the carrying capacity of the area. The shallower laterals and ditch heads were the favored breeding places, but summer water shortage in these places made for very poor breeding conditions. However, numerous small water holes, such as beaver ponds and hollows scoured out in bends and behind drift jams, provided a skeleton system of breeding grounds. These permitted the population to build up during the spring and summer.

Winter conditions were severe. There was a marked shrinkage in muskrat sign between autumn and spring, without corresponding increase in the muskrat waters just outside the Project. It was plain that drastic winter losses had occurred. A critical unbalance between food and water supplies seemed to be responsible.

Food habits will be described in some detail in a later paper (5). A wide variety of foods was eaten, but the most important plants were: "Wideleaf" (*Carex crinita, C. rostrata*); manna grass (*Glyceria* sp.); bugle weed (*Lycopus uniflorus*); pondweeds (*Potamogeton* spp., chiefly *P. epihydrus*), and burreeds (*Sparganium americanum, S. chlorocarpum*). Cat-tail (*Typha latifolia*) was heavily used wherever found, but was so scarce as to be of little importance quantitatively. Spring, summer, and autumn foods were abundant, but there was a distinct shortage of winter foods.

The survey demonstrated that the muskrat range was seriously out of balance. More important for fur management, the maps showed exactly where, and the notes why, range improvement was most necessary. The food habits data pointed out which plants already growing in the region should be increased.

### BEAVER

We found beaver to be well distributed, increasing in numbers, and requiring no special attention other than continued protection. There has been no legal beaver trapping in recent years, but we found some evidence of poaching.

Unlike muskrats, beavers were found in all types of ditches, provided only that there were food trees close by. They were most firmly established in the Project's rather limited deep peat

country where aspen was abundant and danger of spring wash-outs slight. One might say that peat plus fire bring aspen; aspen plus water bring beaver.

Even main ditches with sand spoil-banks were dammed. Although spring flood waters wash around the ends of such dams by cutting through the sand, the dams are repaired or replaced later in the season. Most of the new dams were built in summer and autumn, but a few were started in spring and enlarged later. Dams were plastered with mud on the upstream side during the summer low water stage. Butt ends of the sticks used in dam building were often downstream. Bank burrows were distinctly more common than lodges.

Aspen (*Populus tremuloides*), with willow (*Salix* spp.) second, were the most important winter foods. White birch (*Betula alba* var. *papyrifera*) was occasionally used, and one colony fed on it extensively while also eating an abundant supply of aspen. Alder (*Alnus incana*) and pin cherry (*Prunus pennsylvanica*) cuttings were often seen, the latter perhaps more used in dam building. A few oaks, one six inches in diameter, had been cut. Most of the winter storage piles were round heaps, but one was 150 feet long, six to eight feet wide, and two to three feet high.

During the spring and summer few trees were cut, and foods such as the following were taken: grasses, sedge (*Carex crinita?*), pondweeds (*Potamogeton* spp.), cat-tail roots (*Typha latifolia*); and roots of brake (*Pteris aquilina*), bristly sarsaparilla (*Aralia hispida*), and rose (*Rosa* sp.), which were dug out of the banks in some quantity. The spring change in food habits (already emphasized by Bradt, 6) is probably the result of the greater availability of succulent plants.

The bank roots may have an as yet unknown significance as tonic foods. The concept of tonic foods is but imperfectly understood: Seton (7) approached it in speaking of the muskrat's diet, Leopold (8) has developed it much farther, but it is still little more than a useful hypothesis. The industrious digging in the banks for roots when there was more than enough food of many kinds in the water suggests some nutritional need not met by the sustenance foods. On the other hand, the reason may lie in individual taste, or in a carry-over in feeding habit from an early spring period during which these roots were the only fresh foods other than bark.

### OTTER

In sharp contrast to the widespread, if spotty, distribution of the other fur-bearers, otters were found only in Beaver Creek bottom, the only area of its kind on the Project. Development of new otter range seemed to be impracticable.

Despite the fact that the original creek bed had been straightened by a deep ditch, much of the typical stream-bottom woods cover remained. Many of the cut-off stretches of the old creek have become small sloughs and bayous and these, with a few of its better timbered laterals, made at least one otter territory. In the less disturbed head waters of the same watershed, to the northwest of the Project, otters were somewhat more abundant. There was a well marked otter trail, unbroken through most of its length, connecting the two ranges.

The bottoms of the Yellow River, immediately to the east of the Project, were also otter country. No sign could be found in the eight-mile-wide strip between the Beaver Creek ditch and the Yellow River. The absence of resident otters could be explained by a lack of timber along the ditches. It was surprising, however, that there was no crossing between the two ranges, even though there was an almost complete connection by water and the distance was much less than that covered by the trail to the northwest.

Examination of the otter range on the Project and close by showed the advisability of concentrating any attempts at otter management in the Beaver Creek bottoms. A permanent closed season on the few individuals already present, for their esthetic value, seemed the best move. To duplicate on the poor soils of the Project the dense stream bottom cover to which the otters in this vicinity were confined could be done only at unreasonable expense.

### RACCOON

The raccoon population, while in a somewhat stronger position, was in the main in about the same situation as that of otters. A lack of stream bottoms and rich woods, combined with the trapping of the few remaining raccoons, were considered to be limiting factors. Raccoons will doubtless be benefited by tree and shrub plantings, pond development work, and the establishment of a food patch system, all of which are now in progress, but they cannot be a major item in the fur take for many years. In its present condition the Project is simply not 'coon country, and, as with otter, intensive management would not repay its cost.

### MINK

Hard trapping kept the number of minks at a very low level; hence little sign was found. A special study was needed, but could not be made at the time. The information already gathered, however, will make a starting point for such a study.

### CONCLUSIONS

From the administrative point of view, the survey data are useful in several ways. From the maps and field notes the administrator knows where the fur animals are through the different seasons. He can see at a glance exactly where range improvement is necessary, where it is not needed, and where it would be impracticable. He can tell not only where and why management is needed, but what particular factors he must manipulate. Refuges for rare species can be selected without guesswork. Even without census figures, abundance and distribution of sign can be used in empirical regulation of trapping. Food habits data and general life history material, often of distinct importance in local problems, are included in the field notes. Special problems requiring more detailed study, otherwise perhaps unnoticed on a large area, are brought to his attention. Law enforcement may be helped by the finding of evidence of poaching.

Like any general method, the survey is not applicable to all species with absolute equality. It may well be less suited to mink than to muskrat. It is certainly more usable on streams and ditches than on ponds and lakes. It

does not answer the problem of censusing. However, by censusing sample areas of heavy, medium, and light sign and applying the results to the mileage of inhabited shore shown on the maps, a more accurate population figure could be worked out than the general estimates which are now so frequently used.

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# WILDLIFE FOOD PATCHES IN SOUTHERN WISCONSIN

*Aldo Leopold, Ellwood B. Moore, and Lyle K. Sowls*

Beginning about 1933, hundreds of food patches have been planted yearly in Wisconsin, mostly by the Soil Conservation Service, the Resettlement Administration, and sportsmen's clubs cooperating with the State Conservation Department.

The results have been disappointing, usually for one or more of four reasons: (1) Use of inferior soil; (2) Insufficient size; (3) Broadcast sowing of crops which yield well only under row cultivation; and (4) Shattering, lodging, or exhaustion of the crop before the critical winter period.

The first three causes suggest their own remedies: use good land or else fertilize; make larger patches; do not rely on broadcasting except for crops (like buckwheat) adapted to it.

The fourth cause of disappointment is the critical one. Previous to the killing winter of 1935–36 (1) it was hoped that food patches alone could be relied upon to carry birds through the winter, as they do farther south. In Wisconsin, it is now clear that only corn shocks can be relied upon in all weathers. Supplementary feeding is necessary during the worst part of the winter, especially for quail.

Notwithstanding this important limitation, it is clear that the food patch has positive values not obtainable from more artificial forms of feeding. Its "bait" value (i.e., its power to attract and hold wandering birds in fall) is superior to any feeding station. It involves less risk of predation and is less likely to become a source of infection by parasites and disease. Until covered by snow or exhausted, it demands less attention than the feeding station.

The experiments reported in this paper were an attempt to reappraise the food patch, not as a self-sufficient means of wintering birds, but as a supplement to wild foods, farm crops, and feeding stations.

From this new viewpoint the food patch becomes a technical problem in *design*. For each locality and wildlife population there is a combination of food patch crops, crop residues, natural foods, and feeding stations which offer the *assortment of food properties* needed to meet the exigencies of the seasons in that locality.

The tests[1] here reported were made on the University Arboretum, a tract of 900 acres near Madison, well populated by pheasants and quail. In 1934, 1935, 1936, and 1937 a total of 30 varieties was grown on 90 plots. Each plot contained a different food plant, or represented a different culture or treatment. The series for each year aimed to offer the birds a cafeteria in which their selections would be self-recording. Use of each plot by game

[1] Acknowledgment is made to the Civilian Conservation Corps for labor; to M. E. McCaffrey of [the University Board of Regents for funds for seeds and plowing; to H. W. MacKenzie, State Director of Conservation, for collecting permits; to Prof. A. L. Stone for identification of seeds found in pheasant stomachs; and to Prof. George M. Briggs for agronomical advice.

birds, mammals, and small birds was checked by tracks, sign, flushing, and observation from blinds. In 1936 and 1937 these observations were further verified, in the case of pheasants, by study of a series of 40 stomachs taken weekly through the fall, winter, and early spring.

The conclusions are presented first in terms of seasonal lists, then in terms of plant varieties. The seasonal lists include besides food patch plants the food-producing weeds obtainable on fallow.

## SEASONAL LISTS

*Late summer foods.* Summer foods must either ripen early or be palatable during the green stage.

Crops which ripen early: common millet, winter rye, wheat, buckwheat. The millet is of doubtful value except for small birds.

Palatable during green stage: Canada peas.

Weeds: yellow foxtail (*Setaria glauca*), climbing false buckwheat (*Polygonum scandens*), and panic grass (*Panicum* sp.)

These summer foods were used by pheasants and small birds. We have no evidence that quail ate food patch crops until after ragweed seeds became scarce in fall. Quail, however, patronize the food weeds in summer.

*Fall foods.* The hunting season and the fall shuffle are strong dispersive forces. To counteract them, bait foods must be offered which are more palatable than the wild foods and crop residues so abundant at that season. But fall also brings hordes of migrant birds which often exhaust such baits before they ripen. Hence no general recipe for fall baits can be written. One must learn by local experience what baits will serve local objectives.

Tall bait crops, to be available, must either lodge early or shatter early. Game bait crops which lodge early: feterita, dwarf yellow milo, buckwheat. Game bait crops which shatter early: common hemp would probably be valuable if not exhausted by small birds.

Small bird bait crops: hegari, kafir, sunflowers, hemp, dwarf yellow milo, common millet. Erectness in the first four, and non-shattering in the first three, favor small birds.

Weed baits: lesser ragweed (*Ambrosia artemisiifolia*), yellow foxtail, smartweed, climbing false buckwheat.

*Winter foods.* If these do not stand up in snow they must be stacked.

Foods which stand up must also be too unpalatable to be exhausted in fall, or must have seeds of retarded availability. Thus use of corn is retarded by reason of its tall stalk and protective husk, soybean by reason of its tight pod. Both stand up better than any other known food plants except the stiff-stemmed sorghums. Soybeans, furthermore, are low enough in palatability to escape small bird loss and to postpone heavy consumption by game birds until cold weather.

Retarded crops which stand up: corn, soybeans.

Crops for stacking: buckwheat, rye, wheat, common millet, early amber sorghum, soybeans. Also any of the fall baits that small birds allow to ripen.

Weeds which stand up: lesser ragweed; climbing false buckwheat may be supported.

*Spring foods.* Weak-stemmed plants of low palatability that break down and

remain under the snow until spring, or winter foods planted in large enough quantity to last.

Crops which hold over under the snow: rye, Sudan grass, German millet, common millet.

Winter foods good for spring if the supply is large enough: corn, soybeans, all the crops good for stacking.

We feared at first that shattering grains like rye would work into the ground with the fall frosts and thus become unavailable in spring. The occurrence of rye in spring pheasant crops, however, indicates that these birds scratch it out, even though embedded in the soil.

TABLE 1

PHENOLOGY AND USE OF FOOD CROPS

| Crop | Date planted | Bloom | Milk | Set | Lodged | Ripe | Shattered | Exhausted | Eaten by song birds | Eaten by game birds |
|---|---|---|---|---|---|---|---|---|---|---|
| Corn | 5/25 | 7/25 | 8/ 6 | 9/ 1 | 10/ 1 | 9/20 | none | 4/ 1 | 8/ 1– 9/ 6 | 8/25– 4/ 1 |
| Soybean—Manchu | 5/30 | 8/ 1 | 8/30 | 9/ 9 | none | 9/30 | 2/ 9 | 4/ 1 | none | 10/15– 4/ 1 |
| Soybean—black Wisconsin | 5/30 | 7/25 | 8/ 9 | 8/30 | none | 9/ 1 | 2/ 9 | 4/ 1 | none | 10/15– 4/ 1 |
| Early amber sorghum | 5/30 | 7/ 3 | 8/ 9 | 8/25 | 10/30 | 9/25 | none | 4/ 1 | 10/ 1– 3/ 1 | 10/25– 3/ 1 |
| Dwarf yellow milo | 5/25 | 8/ 1 | 8/20 | 8/30 | 10/15 | 9/20 | none | 12/ 1 | 8/20–12/ 1 | 10/ 8–12/ 1 |
| Hegari | 5/25 | 8/ 7 | 8/12 | 9/ 9 | none | 9/25 | ? | 11/ 7 | 7/21–11/ 7 | 10/ 7–11/ 7 |
| White kafir | 5/25 | 8/15 | 9/ 1 | 9/ 6 | none | 9/12 | 10/20 | 11/15 | 7/21–11/15 | 10– 7–11/15 |
| Feterita | 5/25 | 8/ 1 | 8/20 | 9/ 1 | 10/15 | 8/25 | 10/20 | 11/15 | 7/21–11/15 | 10/ 7–11/15 |
| Common millet | 5/25 | 7/ 7 | 7/14 | 8/14 | 10/ 1 | 8/25 | 9/ 3 | 9/30 | 8/15– 9/30 | 8/15– 9/30 |
| German millet | 5/25 | 7/20 | 8/ 1 | 8/30 | 12/ 1 | 9/ 1 | none | 4/ 1 | 8/ 1– 4/ 1 | none |
| Sudan grass | 5/25 | 7/20 | 8/ 1 | 8/20 | 10/20 | 9/12 | 10/30 | 3/25 | 8/12– 4/ 1 | 3/ 1– 4/15 |
| Rye | previous fall | 5/15 | 6/ 1 | 8/ 1 | 7/12 | 7/ 6 | 7/10 | none | none | 8/ 1– 4/ 1 |
| | Sept. | | | | | | | | | |
| Spring wheat | 4/ 1 | 7/ 9 | 7/13 | 7/16 | 7/30 | 7/30 | none | 8/25 | 7/25– 8/25 | 7/30– 8/25 |
| Sunflower | 5/25 | 7/26 | 8/25 | 9/ 1 | 11/ 1 | 10/8 | none | 11/ 1 | 10/ 8–11/ 1 | 10/20–11/ 1 |
| Buckwheat | 6/ 1 | 7/ 1 | 7/30 | 8/30 | 9/ 1 | 9/10 | 10/ 1 | 11/ 1 | 7/30– | 9/15–11/ 1 |

## VARIETY TESTS

We here present a list of the crops tested, classified according to their properties, with detailed observations on each crop.

### (A) *Weak-stemmed palatable sorghums*

Too weak to stand up during the winter, but seeds palatable enough for fall use.

*Feterita.* Lodged badly in October; the seeds were found in large quantities in pheasant stomachs until exhausted about the middle of November. The great amount eaten during this period, when weed seeds and palatable grains were abundant, indicates high palatability. These properties eliminate feterita both as a stacking crop and as a standing winter crop, but favor it as a fall bait.

Culture: drill rows 3 feet apart at the rate of 6 pounds per acre.

*Dwarf yellow milo.* Taken eagerly by small birds. It lodged in October and was thus made available to game birds early. As a fall bait for game it is not as good as feterita because a larger proportion of the seeds are consumed by small birds.

Culture: drill rows 3 feet apart at the rate of 5 pounds per acre.

*Early amber sorghum.* Shattered little. Lodged badly, usually by bending over and forming a canopy above the ground. However, during one wet fall, it all broke at ground level and became lost under the snow.

Of eight grains tested in hoppers, Hawkins (2) found this the least palatable. In August and September, stalks in food patches were artificially lodged so that the seeds were within easy reach of game birds. No feeding sign developed until the middle of October and it was only after the snowfalls of December that game birds began taking this grain regularly. The food patch tests thus corroborate the hopper tests of palatability.

Quail took this grain more readily than pheasants. It was eaten by small birds during the fall migration, but not exhausted. The droppings of birds which eat it have a purple color.

It may be rated as a good late fall food, but not as a fall bait. It is usable as a stacking crop for winter.

Culture: yielded best when drilled in rows 3 feet apart at the rate of 6 pounds per acre. Broadcasting was a failure.

*Rox orange sorghum.* Tried in 1935. Taller than early amber, but apparently similar in properties.

(B) *Stiff-stemmed unpalatable sorghums*

Stems stiff enough to prevent lodging in winter; seeds unpalatable enough to escape exhaustion during the fall migration.

*Wheatland milo.* Has short, erect heads; stands up well, even in winter. Our only seeding had to be replanted, hence did not mature well. Was used sparingly by game birds, only a few seeds being found in stomachs of the pheasants collected. This low palatability rating coincides with conclusions drawn by Hawkins from hopper tests.

Culture: drill rows 2½ feet apart at the rate of 5 pounds per acre.

(C) *Stiff-stemmed palatable sorghums*

*Hegari.* More resistant to lodging than any other sorghum. It tillers freely and thus furnishes excellent cover. It is so palatable to small birds that the bulk of the seeds were taken during the fall migration by goldfinches, blackbirds, and sparrows. This early exhaustion occurred in the milk stage and was followed by mildew, so game birds had no chance to use it.

It would rate as excellent fall bait where small birds allowed it to ripen.

Culture: drill rows 3 feet apart at the rate of 4 pounds per acre.

*White kafir.* Has the same properties as hegari, except that it does not tiller as much. Exhaustion of both crops by small birds occurred at the same time, so that both were unavailable in winter. A small patch broadcast thickly for cover reached a height of about three feet and looked much like heavy broom sedge.

Culture: drill rows 2½ feet apart at the rate of 6 pounds per acre.

(D) *Small grains*

*Sudan grass.* Low in palatability; rejected by game birds as long as other foods were available. English sparrows and juncos fed upon it occasionally during the winter. In November, the heads broke away from the stalks and were lost under the snow. They became available again in spring, small birds working the ground during April. We rate Sudan as of some value for song birds, but of little use to game except as a spring food.

Culture: broadcast 20 pounds per acre.

*Hog millet or proso; Early fortune millet.* These millets mature and shatter

very early; other properties inconclusive.

*Common millet.* Distinctly a summer small bird crop. It was taken by goldfinches and red-winged blackbirds during August and September, but none was found in the pheasant stomachs collected.

Culture: broadcast 20 pounds per acre.

*German millet.* Low in palatability; taken sparingly by small birds in fall and spring. It was not found in pheasant stomachs, nor was it eaten when bundles were spread out in winter. It resisted lodging surprisingly well, and retained most of its grain in the heads until spring.

Culture: broadcast 20 pounds per acre.

*Spring wheat.* A poor catch was obtained so a fair appraisal cannot be made. Its high palatability in Hawkins' hopper tests indicates that it may be valuable as a summer and fall food.

Culture: broadcast 6 pecks per acre.

*Rye.* Although Hawkins rated rye as unpalatable to game birds when fed in trays, we found it in large quantities in pheasant stomachs during October, and in lesser amounts throughout winter and early spring. Our winter rye began to shatter in July and lodged soon after. Rye re-seeds itself better than any other crop; a fair stand grew the second year without additional seeding or cultivation. We consider rye as a good crop for summer, fall, and spring use, but of no value in winter.

We mixed vetch with rye but found none of its seeds in stomachs.

Winter rye is excellent fall and spring bait for deer.

Culture: broadcast 6 pecks per acre in fall.

(E) *Staple winter foods*

*Soybeans.* We tried four varieties: Mukden, Manchu, Illini, and early black Wisconsin. All stand up well in snow and ice, their seeds being about 75 per cent available despite six inches of snow. Shattering of pods began in February but was gradual, many beans being retained in the pods until spring.

Soybeans first appeared in pheasant stomachs about October 15 and continued to be an important food throughout the winter and early spring. Quail readily took soybeans, and on many occasions they preferred them to corn when both were available. We detected no difference in palatability among the four varieties.

Schmidt (3) lists soybeans as preferred food for both sharp-tailed and pinnated grouse.

The soybean plots were damaged by deer. Where deer are present, it is doubtful practice to include soybeans in the food patch for game birds. Where it is desired to attract deer, soybeans are excellent bait.

No damage was caused by small birds.

Culture: drill in 2½ foot rows at 50 pounds per acre.

Soybeans planted with corn provide some food on fields where corn cannot be left over winter, but such soybeans are knocked down during the corn cutting hence are liable to be buried in snow.

*Corn.* Yellow dent corn was the food most sought by pheasants at all seasons. Large quantities were eaten while the corn was in the milk stage. This early

availability was caused by blackbirds, which tore open the husks. From this evidence we suspect that the usual absence of corn from stomachs of pheasants collected in early fall is due to the greater availability of weed seeds, rather than to preference for them.

During the winter, pheasants regularly walked over bundles of other grains in order to reach corn, the ears of which were often partly buried under snow and ice. Yellow corn was taken in preference to white.

Under the same field conditions, quail rarely fed on corn, but directed their attention to the smaller grains, particularly early amber sorghum and the soybeans. At feeding stations, however, where ear corn was used exclusively, quail readily accepted it.

In Hawkins' hopper tests, corn headed the list for palatability to quail as well as to pheasants. There is thus a discrepancy between hopper and field tests of corn for quail.

Corn shocks left in the field are the most complete single method of winter feeding all game, including deer. Standing corn has more bait value, but is more likely to be covered by snow.

Culture: drill rows 3 feet apart at the rate of 7 pounds per acre. Corn broadcast in mixtures set no ears.

(F) *Miscellaneous*

*Sweet corn.* While in the milk stage, the soft ears were eaten by raccoons or opossums. Hamilton (4) found that corn and buckwheat were important foods of the raccoon in New York. They could probably be used as food patch grains for raccoons.

Our experiments showed no difference in palatability to game birds between sweet corn and yellow corn.

*Jerusalem artichoke.* Leopold (5) learned that this is an important food for pheasants and roe deer in Germany. We tried it in 1937, when a patch yielded well on poor soil despite dry weather. Striped spermophiles ate the leaves during the summer.

The tubers of a few plants plowed up in the early fall were eagerly eaten by the pheasants. When these were gone, others, slightly exposed by erosion, were discovered and eaten, and the pheasants soon learned to dig for more and so continue until frost. During January we dug up several hills of tubers. Tney soon froze solid and were rejected by pheasants.

We believe this crop will prove valuable as a fall and spring pheasant food, but the tubers cannot be left exposed over the winter, as is done in Europe.

Paul B. Riis found artichokes to be a good bait for modifying the distribution of deer on an overstocked range near Rockford, Illinois. The tops as well as the tubers were eaten.

In 1938 our patch showed a dense spread from every 1937 clump. This aggressiveness warns us that Jerusalem artichoke should not be planted unless bordered by heavy sod so that it cannot escape.

Culture: rows 3 feet apart, 2 tubers per hill, hills 1½ feet apart.

*Canada peas.* High in palatability; eaten by quail and pheasants while still in the milk stage in early July. Striped spermophiles took about one-half of the peas, causing exhaustion of the crop before August 15.

Culture: drill in 2-foot rows at the rate of 3 bushels per acre.

*Buckwheat.* Both common and Tartarian buckwheat were tried. They lodged early and were covered by snow during most of the critical period.

Both quail and pheasants were flushed from the buckwheat plots in fall, but very little feeding sign was found, and the grain did not appear in the pheasant stomachs. Hawkins learned, however, that it ranked high in palatability when fed in trays.

In central Wisconsin Schmidt found buckwheat to be good fall and spring food for the sharp-tailed grouse, prairie chicken and sandhill crane, and also a winter food if shocked.

Culture: broadcast 50 pounds per acre.

*Hemp.* Both Manchurian and common hemp were tried. Each was drilled and also broadcast. The common hemp grew taller than the Manchurian but both made fair cover, especially where broadcast. Both produced a large amount of seed which was all eaten by small birds beginning in the milk. It was all gone by October. Hemp must occasionally escape exhaustion by song birds, for Allen (6) reports pheasants using it in January.

Common hemp shatters early. Manchurian hemp is alleged not to shatter, but we were unable to verify this point because of its early exhaustion.

A federal permit to grow hemp is required because of its use as a narcotic.

Culture: broadcast 40 pounds per acre or drill in 4-foot rows at the rate of 5 pounds per acre.

*Sunflowers.* Cox (unpublished) found that sunflowers wintered game birds in Minnesota. In our trials song birds ate the entire crop of seeds in early fall, leaving none for the game birds. This occurred regardless of the size of the plot.

Culture: drill in rows at the rate of 5 pounds per acre.

### CULTURE OF FOOD PATCH CROPS

Our experiments indicate that food patches are not worth while on soil not fertile enough for corn. Where it is impossible to locate the patch on good soil, it is necessary to fertilize.

Our results with broadcasting of mixtures were poor. This runs counter to the findings of Wight (7) and Allen in Michigan. In our trials, mixtures planted in rows and cultivated produced better than those which were broadcast.

### CULTURE FOR FOOD WEEDS

The weeds which come up on fallow may be food weeds (like ragweed, smartweed, yellow foxtail, panic grass, climbing false buckwheat) or they may be species without food value (like horseweed, *Erigeron canadensis*, prickly lettuce, *Lactuca scariola*, sow thistle, *Sonchus* sp.).

What weeds one gets on fallow depend on what seeds are stored (6) in the soil and whether, how, and when the soil is cultivated. It is not yet possible to predict the food weeds resulting on any given soil from any given preparatory treatment except on the basis of local experience.

In our experiments, either ragweed, foxtail, or smartweed usually followed the fallowing of any *good* soil, no matter what the treatment. In low spots and in wet years smartweed usually came; in dryer spots and dry years, ragweed or foxtail.

On *poor dry* fallows foxtail sometimes

came in, but never ragweed or smartweed. Poor dry soils, however, often yielded only worthless species. Poor dry sands should never be fallowed for weeds as they produce sandburs (*Cenchrus carolinianus*).

Moister sands may yield foxtail the first year and still more valuable panic grass the second and third years. Panic is valuable summer bait for doves, but is exhausted by doves and rodents before fall.

Climbing false buckwheat may come in on any soil from poor dry sands to good corn land.

### DESIGNING THE PATCH

With the foregoing properties of plants in mind, the wildlife manager is ready to select, for any given spot, those varieties of food patch plants which: (1) Fit the soil; (2) Tend to hold or sustain the desired animal species; (3) Fill local gaps in wild foods, crop residues, and cover; and (4) Shorten the period for maintaining artificial feeding stations.

There remain only the questions of size and location of the patch.

*Size.* As pointed out by Hawkins, this varies not only with the population to be fed and the amount of wild foods and crop residues available, but with fluctuating wastage by rodents and the unpredictable length of pinch periods. Our experience indicates that ¼ to ½ acre is good, if some degree of winter use is contemplated. If the patch is for fall bait only, ⅛ acre will often suffice.

If the patch is to be rotated with fallow either to supply weeds or maintain fertility, then the area reserved must be double or triple that actually planted.

Correct forecast of needed size is especially important in patches which must be fenced against livestock. Fencing is necessary not only in pastures but also in fields where stock is turned loose to glean the stubble in fall.

TABLE 2

KEY FOR DESIGN OF FOOD PATCHES

A. Supplementary Food Patch. Hopper, rack, or other artificial feeding to be added during severe weather.
Rotated patch for game
Fall bait not needed
⅓ corn, ⅓ soybeans, ⅓ fallow.
Fall bait needed
⅓ buckwheat or feterita, ⅓ soybeans or corn, ⅓ fallow.
Non-rotated patch for game
Fall bait not needed
½ corn, ½ soybeans.
Fall bait needed
½ buckwheat or feterita, ½ corn or soybeans.
For song birds add to any of above:
For summer: common millet, hemp, sunflower.
For fall: hegari, white kafir, dwarf yellow milo.
For spring: German millet or Sudan.

B. All-winter Food Patch. Add to any of above shocked corn, or stacked soybeans, buckwheat, rye, or sorghum. Open shocks or stack from time to time during the winter.

Table 2 presents a rough key for the design of food patches.

*Location.* Where corn is used, squirrels are present, and economy necessary, locations in woods should be avoided.

Patches for quail must be near cover, or near travel-lanes to cover. Patches for prairie chickens and Hungarian partridge must be in open areas, the more open the better. Grass cover nearby is good, but not large blocks of brush or timber. Patches for pheasants may be either in, near, or far from cover.

All game birds gravitate toward

marshes in severe weather. High upland patches may fail to hold quail and pheasants unless the cover is extra good.

### COMPARISON WITH HOPPER TESTS

The palatability ratings of foods offered in patches did not always coincide with those for the same items offered in hoppers. Why? We here doubtless encounter the boundaries of the unknown. Most animal research proceeds on the assumption that corn is corn and quail are quail; i.e., a species is a homogeneous entity within which any two individuals, at a given time and place, will behave alike.

Dove (7) has proved the fallacy of this assumption. He points out that slight differences in heredity, magnified by differences in environment and experience, produce decided individuality among domestic chickens in selection of foods.

Similar variability is certainly to be expected between individuals or local groups in any wild species. Unfortunately, wildlife managers have not devised experimental techniques that bring out this variability. Dove has accomplished this difficult feat.

Aside from variations in palatability traceable to the animal, a given food doubtless exhibits variations in chemical condition on different sites and under different conditions of curing and storage. These may account for discrepancies between patch and hopper tests. For example, in the hopper tests Hawkins found year-old barley used in 1937 to be lower in palatability than when fresh in 1936. Year-old buckwheat, however, was more palatable than fresh buckwheat.

It is clear, then, that we should not expect complete consistency in food selection, and that we do not get it because there are variations within each kind of food and each kind of bird. All "recipes" laid down in this paper are therefore only rules of thumb which *usually* work.

The principles of design, however, may approach the status of dependable ecology. By clothing these principles with his own local experience, the wildlife manager can gradually improve his field practice.

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# SIZE OF SETS OF EGGS OF THE AMERICAN EIDER

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For five summers, from 1934 to 1938 inclusive, I have made special record of the number of eggs of the American Eider Duck (*Somateria mollissima dresseri*) in the nests of this subspecies observed on the north shore of the Gulf of St. Lawrence, in Saguenay County, Quebec. In a few instances, in which broods of newly-hatched young were still in the nest, these were included in the record as though they had not yet hatched. Young Eiders are, of course, in the nest only a few hours after hatching. Most of the data in this record are derived from my personal observations, but a few were contributed by observers accompanying me. Variation in the number of nests observed and recorded from year to year does not indicate fluctuation in the number of American Eiders nesting in this region, but rather variation in my summer program of activities.

The record of 1,131 nests observed during the five summers mentioned is presented in concise form in Table I. The dates on and between which these data were obtained are as follows:

1934 June 12th to July 26th.
1935 June 23rd to July 13th.
1936 June 9th to July 12th.
1937 June 2nd to July 22nd.
1938 May 26th to July 12th.

In compiling the records that make up Table I, no nests were deliberately excluded. Since the nature of my official duties required that I travel almost continually, it was impracticable to keep any nests under daily observation; hence, in some of the nests, especially those observed in May, 1938, the sets of eggs, no doubt, were not yet complete when the numbers of eggs were recorded. On the other hand some of the sets had doubtless been reduced in size by predators. It is believed that the Great Black-backed Gull (*Larus marinus*), the Eastern Crow (*Corvus brachyrhynchos brachyrhynchos*), and the Northern Raven (*Corvus corax principalis*) are the predators chiefly responsible for depredations. It is also entirely probable that some of the sets recorded were smaller than normal first sets because they were actually second sets laid after the first had been unlawfully taken by man. Of the total number of sets recorded, the proportion that lacked normal size for any of these reasons is believed, however, to be small. Nests containing second sets or sets reduced by predators could very seldom be recognized with certainty. Reduction of the number of eggs in these ways may, moreover, be viewed as normal, due to certain elements, some of which are human, in the ecology of the Eider Ducks. The actual norm in the number of Eider eggs in a set in a given region, as distinguished from the possible or theoretical norm, may be considered to be the result of the interplay of such checks and of the egg-production of the ducks. While some of the earliest sets of eggs seen in 1938 might justifiably have been left out of the record on the ground that they were incomplete, the sets that might have been so omitted with rea-

sonable certainty are very few and the latest date on which such sets were found cannot be clearly determined. All nest records, therefore, are included in the table, which should give a close approximation to the normal distribution of sizes of sets of eggs of this subspecies in this area.

totals for the five summers under discussion show no change in their relative order for the first four summers, but a notable change in 1938, when five, instead of four, was the most frequent number of eggs in a set, followed in order by four, three, six, and two. In other words, sets of five and six eggs each were more frequent in 1938 than in any of the previous four summers, while those of four and three eggs each were reduced in frequency. In harmony with these facts it will be noted that the average number of Eider eggs in a set in this region in 1938 was 4.25, which is .24 egg more than in any of the

TABLE I

RECORD OF SIZES OF SETS OF EGGS OF THE AMERICAN EIDER ON THE NORTH SHORE OF THE GULF OF ST. LAWRENCE

| Numerical Sizes of Sets of Eggs | Number of Sets of Each Size | | | | | Totals | |
|---|---|---|---|---|---|---|---|
| | 1934 | 1935 | 1936 | 1937 | 1938 | Sets | Eggs |
| 1 | 2 | 5 | 1 | 13 | 6 | 27 | 27 |
| 2 | 15 | 15 | 2 | 29 | 18 | 79 | 158 |
| 3 | 43 | 52 | 9 | 71 | 40 | 215 | 645 |
| 4 | 81 | 110 | 14 | 123 | 77 | 405 | 1,620 |
| 5 | 54 | 76 | 12 | 100 | 95 | 337 | 1,685 |
| 6 | 11 | 7 | | 16 | 21 | 55 | 330 |
| 7 | 2 | 1 | | 1 | 2 | 6 | 42 |
| 8 | | 1 | | 2 | 3 | 6 | 48 |
| 10 | | | | | 1 | 1 | 10 |
| Totals | 208 | 267 | 38 | 355 | 263 | 1,131 | 4,565 |
| Average No. Eggs Per Set | 4.01 | 4.00 | 3.89 | 3.93 | 4.25 | 4.04 | |
| Numerical Sizes of Sets of Eggs | Percentages of Sets of Each Size | | | | | | |
| 1 | .96 | 1.87 | 2.63 | 3.66 | 2.28 | 2.39 | |
| 2 | 7.21 | 5.62 | 5.26 | 8.17 | 6.84 | 6.98 | |
| 3 | 20.67 | 19.48 | 23.68 | 20.00 | 15.21 | 19.01 | |
| 4 | 38.94 | 41.20 | 36.84 | 34.65 | 29.28 | 35.81 | |
| 5 | 25.96 | 28.46 | 31.58 | 28.17 | 36.12 | 29.80 | |
| 6 | 5.29 | 2.62 | | 4.51 | 7.98 | 4.86 | |
| 7 | .96 | .37 | | .28 | .76 | .53 | |
| 8 | | .37 | | .56 | 1.14 | .53 | |
| 10 | | | | | .38 | .09 | |

Examination of Table I shows that, in the region in which this information was obtained, the most frequent number of eggs in a nest of the American Eider is four. This is followed by five, three, two, and six, in descending order of frequency. The records of percentages of sets of these sizes in the annual

four previous years. This result appears despite the fact that the record for 1938 was begun earlier in the season than that for any of the four previous years and presumably includes, therefore, more incomplete sets of eggs than does any of the other annual lists.

Why the average size of a set of Eider eggs on the north shore of the Gulf of St. Lawrence should have been greater in 1938, by differences varying from .24 to .36 egg, than the average for any of the four preceding years I do not know. One might be tempted to ascribe the change to improved protection of the eggs against unlawful removal by man, but I do not believe that this would affect the relative position of sets of the larger sizes and cause those of five eggs each to be more frequent than those of four, as they apparently were in 1938. The snowfall on the north shore of the Gulf of St. Lawrence was phenomenally light in the winter of 1937–38. Consequently the islands on which Eiders nest along that shore were almost wholly bare of snow in 1938 much earlier in the spring than usual and long before the Eider Ducks were ready to nest. Drift ice was almost wholly absent from the sea about those islands during the entire nesting season of 1938. Consequently the Eider Ducks had easy access at all times to the supplies of their usual foods on the sea-bottom in shoal areas. It may be that one or both of these very favorable conditions played a part in bringing about an unusually high production of Eider eggs in 1938. More light on this matter will be sought through future investigations.

The data recorded in Table I appear to justify us in concluding that, on the coastal islands of the north shore of the Gulf of St. Lawrence, the average number of eggs of the American Eider Duck in a set is about four; that the average varies somewhat from year to year; and that it is more likely to be slightly greater than four than than it is to be less.

With a view to determining whether the numerical average of sets of Eider eggs found in the first part of the nesting season differs from that of sets found later in the summer, I have sorted the data into two lots, as shown in Table II.

This table indicates that, in the region under consideration, the average numerical size of a set of Eider eggs is

TABLE II

SIZES OF SETS OF EGGS OF THE AMERICAN EIDER

*Grouped According to Time of Observation*

| Year | Average Numerical Size Prior to June 16 | Average Numerical Size after June 15 |
|---|---|---|
| 1934 | 3.62 | 4.07 |
| 1935 | — | 4.00 |
| 1936 | 3.76 | 4.06 |
| 1937 | 3.90 | 4.01 |
| 1938 | 4.19 | 4.33 |
| 1934–1938, inclusive | 3.97 | 4.08 |

greater in that part of the nesting season after the middle of June than in the preceding part of the season. Possibly this is due to inclusion of a number of incomplete sets in the records for the first part of the season and to more extensive losses of eggs by predation before mid-June than subsequent to that time. Destruction of Eider eggs in this region by predators decreases practically to nothing about the middle of June. This is probably brought about chiefly by two changes in related conditions—the development of grass, other herbaceous vegetation, and the leaves of alders and other bushes, providing good shelter for many Eider nests that previously lacked it, and the arrival in shallow coastal waters of large schools of small fish, the capelin (*Mallotus villosus*), which furnish an abundant supply of food for predators and thus reduce greatly their destruction of Eider eggs. On the other hand, the average numerical size of sets of Eider eggs observed after mid-June is subject to reduction through the fact that, during that period, some of the nests found contain incomplete (second) sets and others contain second sets that, while they are complete, are nevertheless smaller than complete first sets.

It should, however, also be noted that, owing to the way in which my annual activities on the north shore of the Gulf of St. Lawrence are necessarily arranged, many of my observations in the first half of the Eiders' nesting season are made in the more western archipelagoes along that coast, while my observations during the second half of that season are made chiefly in the more eastern archipelagoes, those nearer to the Strait of Belle Isle. Should there be any difference in the average numerical size of sets of Eider eggs in these two geographical areas, I am not, because of the circumstances mentioned, in a position to distinguish it with certainty from any possible difference in the average numerical size of such sets in the earlier and later parts of the nesting season.

Some additional data on the size of sets of eggs of the American Eider Duck are to be found in a recent publication by A. O. Gross (*Auk*, 55: 387–400, 1938).

Harrison F. Lewis
National Parks Bureau
Ottawa, Canada

## OBITUARY

Earl E. Hoover, biologist of the New Hampshire State Department of Fish and Game and Associate Member of The Wildlife Society, died at Concord on January 8, after an illness of several weeks. Professor Carl L. Hubbs writes that Hoover "was perhaps the most promising of the younger workers in the field of fresh-water fish management. His third annual survey report, only recently published, was a tribute to his dynamic energy and thorough competence. He made contributions to herpetology as well as ichthyology and fisheries research, and was engaged in a brilliant research dealing with the effect of altered periods of daylight on the time of reproduction in trout. An investigation of dwarfing in trout, from the systematic as well as fisheries viewpoint, was well under way and was to have been utilized for a doctorate dissertation at the University of Michigan.

"Hoover was born at Somerset, Pennsylvania, December 5, 1911. His undergraduate studies were carried on at Lebanon Valley College, and graduate work was done at Johns Hopkins University, where he served as instructor in 1934–35. Before assuming his position in New Hampshire in 1936, he worked as field zoologist in the National Park Service. Despite this tragically short career, Earl Hoover made many friends, and a very real impression in several fields of scientific endeavor. His loss will be keenly felt but his accomplishments will live on."

## REVIEWS

NEEDHAM, PAUL R. Trout streams. Conditions that determine their productivity and suggestions for stream and lake management. Comstock Publishing Co. (Ithaca, N. Y., $3.00 a copy), 233 pp., frontispiece, 74 figs., 36 tables. 1938.

Management of aquatic resources seems to be developing more rapidly than that of upland wildlife and this book is a worthy addition to the already valuable library of the fish conservationist. It deals with the characteristics, distribution, and habits of the principal species of salmon, trout, and charr of North America and with the appraisal and management of their environment. These latter phases are treated under the headings of Stream conditions, physical and chemical, Trout stream animals, Food selection by trout, Distribution of trout foods, Propagation, stocking, and protection, and Stream and lake management. An appendix discusses the names of trout, gives instructions for collecting fish scales, fish planting tables, organization of stream and lake survey crews, methods of locating streams on maps, and blank forms for use of survey crews. There is a 7-page bibliography and an index of similar length. A well prepared and useful book.—W.L.M.

MCATEE, W. L. Wildfowl Food Plants: Their Value, Propagation, and Management. Collegiate Press (Ames, Iowa, $1.50 a copy), 141 pp., 17 pls., 4 figs., tables, January 1939.

The crisis in American waterfowl,

which reached its gravest aspects in 1934 when the populations of ducks and geese touched an all-time low, has focussed on the welfare of this great group of game birds attention never before accorded it. Surveys demonstrated the fact that notwithstanding the alarming shrinkage in waterfowl nesting territory, incident to the extension of agriculture and grazing, the numbers of waterfowl returning to the nesting grounds in spring were woefully inadequate to occupy even the limited breeding areas left. Immediate attempts, therefore, were made to restrict the annual kill by hunters; and at the same time an elaborate system of Federal refuges was inaugurated, designed to provide the birds with food and protection, not only on their breeding grounds, but along their flyways as well.

The proper selection of these refuges demanded a great deal of information on waterfowl requirements, but although much of this information was already possessed by the agency needing it most—the U. S. Biological Survey—the great majority of it was in the form of stomach analysis records, manuscript reports, and other unpublished forms more or less inaccessible to the public.

The expansion of the Federal refuge program has given tremendous impetus to the whole refuge idea. The list of State and private refuges grows daily, and even the farm pond has come to be recognized as a potential duck breeding or resting area.

It was in fact the latter type of water area and the possibility of improving it to waterfowl advantage that first turned the reviewer's attention to the subject. In the course of a water conservation program that for several years has been vigorously prosecuted throughout the drier parts of the Great Plains and the West, hundreds, even thousands of ponds and lakes have been created where little or no open water previously occurred, and it is at once apparent to the wildlife technician that, if he only knew exactly what to do, he might turn these reservoirs into veritable wildlife havens. He knew, of course, that waterfowl, like most other forms of wildlife, had to have food and cover. He thought he could pretty well take care of the cover situation by fencing the areas against livestock, and he knew in a general way what groups of plants were important as food; but the particular food plant species adapted to particular situations, the methods of establishing such plants, and so on, were specific items of information badly needed, but not to be found in usable form in the literature.

Fortunately that need is now supplied, and by a man who, more than any other one person, has been reponsible for the accumulation of the priceless mass of data in Biological Survey files—W. L. McAtee.

McAtee's work with waterfowl food plants and their requirements began in 1905, so his book (which was completed in manuscript in 1935) represents the fruits of 30 years of study that took him on personal investigations to every important waterfowl breeding and wintering area in the country save the two Dakotas. It, therefore, becomes the most authoritative work of its kind, and has come from the press just in time to be reviewed in the present issue of THE JOURNAL OF WILDLIFE MANAGEMENT.

The author has arranged his material in seven chapters, the first of which discusses briefly the productivity, food value, and wildfowl utilization of aquatic plants. Then follows the longest chapter of the book (64 pages), which treats the important food plants by families, giving notes on their variety, recognition, ecology, and use by waterfowl. It is here, as might be expected, that one finds the greatest volume of information needed by the wildlife manager, and also some surprising bits of fact. At first glance the data would lead one to suspect that—as McAtee himself might put it—everything is grist that comes to the mill, for the list of waterfowl foods runs the gamut from the lowly algae to hickory nuts. Closer study, however, reveals that it is the mallard which seems to take everything coming his way—and in amazing amounts. One bird, for example has been known to consume at one feeding 36,000 seeds of Polygonum, while another made a meal of no less than 115,600 Jussiaea seeds!

Of all the food plants treated, the pondweeds are the most numerous in species, and are stated to be the most important to wildfowl of all submerged aquatics. Of Potamogeton, it is considered probable that every species of American wildfowl at times devours their seeds. In the order of importance as wildfowl foods the pondweeds are followed by the sedges, and then the grasses.

Chapters are devoted to environmental limitations on the growth of aquatic plants, as illumination, fertility, quality of water, and pollution; to planting suggestions including storing and handling, together with recommendations of plants for particular environments; to construction of ponds for various sites, and preparation of planting areas; and to control of undesirable plants and animals. There is also a glossary of vernacular names of wildfowl food plants, a bibliography of 37 titles, and a 15-page index.

It is the discussion of plants for particular environments that interests the reviewer most, for fitting the plant to the site is the perennial problem facing the wildlife manager attempting to build aquatic habitats where none previously existed. Therefore, that section alone is worth the price of the whole book.

As a matter of fact, the only criticism the reviewer would offer concerns the list of vernacular names of plants. These names would have been far more useful had they been incorporated with the species discussions in Chapter II, or, better still, placed in the index with appropriate cross references. Criticism of this kind, however, smacks of cavilling when we consider the excellence of the work as a whole, the authority of the author in the field covered, and the crying need for the information presented. No wildlife manager or administrator can afford to be without the work.—Ernest G. Holt.

## NOTES

The American Wildlife Institute has announced that headquarters of the Fourth North American Wildlife Conference to be held in Detroit, Michigan, February 13–17, 1939, will be the Hotel Statler. Rates for rooms start upwards

from the following: Single, $2.50; two persons, double bed $4.50, twin beds $5.00; three persons, $6.50. The Wildlife Institute is sending to each member of The Wildlife Society a statement of the complete schedule of rates and a hotel reservation card for making room reservations.

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The third annual meeting of The Wildlife Society will be held in Detroit, Michigan, at 8:15 p.m., February 13. The location will be announced at the various sessions of the North American Wildlife Conference held that day, and will be posted in conspicuous places in the Hotel Statler. Arrangements are also being made for a supper for Society members, to precede the business meeting, at which the Nominating Committee will announce its recommendations for the slate of officers for the ensuing year. The charge for the supper will not exceed one dollar, exclusive of State tax. Wives and friends of members are cordially invited. Associate Members are of course expected to participate in both the social gathering and the business meeting and to take an active part in any discussions. According to the Constitution, however, only Active Members may vote.

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Elections by mail ballot of Regional Representatives, to take office at the close of the annual meeting February 13, 1939, resulted as follows: For Region 1, Neil W. Hosley; Region 2, H. L. Stoddard; Region 3, Gustav Swanson; Region 4, Olaus Murie; Region 5, Charles T. Vorhies; and Region 6, E. Lowell Sumner, Jr.

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In connection with the gathering of the Texas Academy of Science in Waco, November 11–12, 1938, a meeting of The Wildlife Society, Region 5, was held. Dr. C. T. Vorhies of the University of Arizona was elected Director, and W. C. Parker of the Agricultural and Mechanical College of Texas, Secretary.

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The Wildlife Society, Region 1, is to meet in conjunction with the New England Game Conference in the Statler Hotel, Boston, Massachusetts, February 3–4, 1939. It is planned to adopt By Laws for the Section and elect a Chairman who shall serve as liaison officer between the Section and the Society.

Some of the wildlife management group apparently do not appreciate the value, both to themselves and to others, of a standardized signature. Librarians and bibliographers realize the convenience and importance of author's names being invariably written in the same way and in full if needed for certain identification. In signing a publication, no John Smith, for example, should write J. Smith or Jack Smith, but if he fortunately has a middle name and uses a signature like John Hamilton Smith, he will certainly identify his contribution and assure unerring handling of the reference.

# CORRESPONDENCE

The following letter summarizing work, and stating policies, of the TVA with respect to wildlife should be of interest to members of The Wildlife Society.

TENNESSEE VALLEY AUTHORITY
Norris, Tennessee

October 13, 1938.

Mr. Victor H. Cahalane,
Wildlife Society,
National Park Service,
Washington, D. C.
Dear Mr. Cahalane:

Your letter addressed as of September 28 to the Board of Directors, has been delivered to me for reply. Permit me to assure you that the TVA welcomes the opportunity you present to correct briefly some impressions which may perhaps have resulted from certain statements made by Mr. Edward C. M. Richards, in the July issue of the *Journal of Forestry*. The TVA is glad to do this because we feel that the work done in biological readjustment by the Department of Forestry Relations, is making distinct progress in an aggressive manner upon the complicated wildlife and fisheries problems of the Tennessee Valley.

In order to present the program of game and fisheries investigations now being carried on by the TVA, permit me to offer in outline form the policies involved in these two lines of activities. Any comments which the Wildlife Society may care to make regarding these policies will be gladly received.

GAME POLICY

1. To rehabilitate the native game species as an integral part of the program of wise use of marginal lands;
2. To do this through environment improvement by the planting of food and shelter species of trees and shrubs;
3. To do this as economically as possible, by the use of CCC labor and facilities when available;
4. To do this upon a scientific basis, under the guidance of trained game technicians;
5. To develop those native game species which are naturally suited to the environment upon the principle that "nature knows best"; thus avoiding the introduction of exotic forms which may or may not survive, and which, if they do survive, may prove a handicap to the native game which is best suited to the area;
6. To study the native game species in order to be able to develop an environment best suited to the various needs involved;
7. To establish migratory waterfowl refuges where such refuges are by the nature of the land, indicated;
8. To make game and bag censuses, with a view of determining the best policy concerning the taking of game;
9. To cooperate with the Biological survey, the Conservation Commissions of the States involved, and with local agencies, in order to bring all interested agencies to work together on a common problem.

In order to promote this program and to carry out the policy indicated, a detailed study-survey is made of each reservoir area, with a view of determining those areas best suited for game (or fisheries) purposes, and upon the rec-

ommendations resulting from these reports, certain areas are set aside for wildlife purposes. Thus, upon Norris Reservoir, the TVA has established three game management areas with a total acreage of 10,505. Here quail, grouse, deer, and other animal forms are being studied. The quail and grouse are native to the area; the deer have been introduced from the nearest possible source, the Pisgah National Forest. On the Wheeler Reservoir, some 40,000 acres have been set aside and the Wheeler Migratory Waterfowl Refuge created by Executive Order, to be handled conjointly by the Biological Survey and the TVA. Upon these areas some 270,000 food and shelter species of trees and shrubs have been planted to date. Studies of food habits, migration, distribution and abundance have been made upon various species of game birds; fur-take censuses have been undertaken starting with 1933, in an effort to determine the effects of impoundage upon mammals. The Biological Readjustment Division has on file in its office 85 fact-finding and technical reports based upon studies, surveys and investigations in the field of its activities.

FISHERIES POLICY

1. To study the development of impounded waters from a bio-chemical, bio-physical and biological viewpoint;
2. To attempt to get at an understanding of the cyclic behavior of these waters, and to find the periodicity and causes of these cycles;
3. To correlate the findings with the production of an annual fisheries yield which shall be as nearly maximum as possible;
4. To ascertain what fish species are present before impoundage, and to determine the effects of impoundage upon them;
5. To study the effects of impoundage upon growth rates, productivity, migration, food habits, diseases and other vital factors in the life of the fish species;
6. To determine the interaction of species with a view of controlling those which prove harmful if possible, and to encourage those which prove to be beneficial;
7. To produce through hatchery methods the best species suitable to the various reservoirs on the basis of the aquatic studies;
8. To inventory the fish population and to make creel censuses as a basis for recommendations concerning legislation, yield, etc.;
9. To cooperate with the U. S. Bureau of Fisheries, with the State Fish and Game Commissions, and with the local agencies interested in fisheries, so as to promote the closest possible harmony in the attack upon fisheries problems.
10. To cooperate with other TVA departments in the solution of the fisheries problems when their interests border on those of this Division.

As a start toward carrying out this policy, the TVA has in operation two fully equipped laboratory boats; one of these is on the isolated Norris Reservoir; the other has or will have range from Chickamauga to Gilbertsville Reservoir, inclusive. A small fish hatchery has been constructed in association with Norris Reservoir, and a very large hatchery is under construction which will supply the reservoirs from

Chickamauga to Gilbertsville, inclusive; these hatcheries are run by the U. S. Bureau of Fisheries upon completion, and are constructed in close cooperation with that Bureau. Five permanent level rearing ponds are completed, and two more are under construction. Census work has begun, and experiments in artificial fertilization of the reservoirs through planting operations are being carried on. A personnel of seven men is on permanent assignment in this field. Although the major interest of your organization centers probably in fish and game, your mention of the forest for game cover encourages us to outline the activities of the Authority in other than the strictly wildlife field.

Since its inception, the Tennessee Valley Authority has been engaged in a program of forest restoration and betterment throughout the Tennessee Valley. The activities of the Forestry Relations Department consist of the collection and compilation of basic data necessary to determine the various forestry problems and suggest remedial measures, investigations and demonstrations of forest influences and forestry practices, reforestation, erosion control on submarginal lands through reforestation and upstream engineering, cooperation in fire protection, investigation and developments of tree crops to encourage the growing of special nut and fruit varieties for human consumption and for game food, and a host of other activities. Up to July of this year, almost 62,000,000 trees were planted by the Tennessee Valley Authority or in cooperation with other agencies. Two forest nurseries with an annual production of 23,000,000 trees are operated. Nineteen CCC camps engaging close to 4,000 men are working on these projects.

On these activities, the Authority has spent close to $2,000,000 in the last five years, and believes that it is making a significant contribution to conservation in the Tennessee Valley, particularly so since most of these funds have been expended in cooperation with local agencies to assist them in the attainment of their conservation objectives.

Yours very truly,

TENNESSEE VALLEY AUTHORITY
Neil Bass,
Chief Conservation Engineer.

## EMPLOYMENT SERVICE OF THE WILDLIFE SOCIETY

Space limitations will not permit use of the regular heading and explanation. The notices follow:

The United States Civil Service announces examinations for Biologist (wildlife), $3,800 a year; Associate Biologist (wildlife), $3,200 a year; and Assistant Biologist (wildlife), $2,600 a year, in the Bureau of Biological Survey, Forest Service, and Soil Conservation Service, U. S. Department of Agriculture. Applications must be on file with the United States Civil Service Commission at Washington, D. C., not later than the following dates: (a) February 21, 1939, if received from States other than those named in (b) below. (b) February 24, 1939, if received from the following states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Circulars relating to the duties of the positions and qualifications of applicants may be obtained from the Civil Service Commission.

GREEN, EDWIN L., JR., 328 Moore St., Columbia S. C. M.S. (Biology) University of Tennessee, 1933. Ass't Biologist, U. S. Bureau of Fisheries 7 months, 1934. Three and one-half years as Ass't Wildlife Technician, Sr. Foreman (Wildlife), and Jr. Biologist, National Park Service. Position terminated by lack of funds. Desire position in research, teaching, or wildlife management.